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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : **E04B 5/48** — **A1**

(11) International Publication Number: **WO 91/19863**

(43) International Publication Date: 26 December 1991 (26.12.91)

(21) International Application Number: PCT/US91/04141

(22) International Filing Date: 18 June 1991 (18.06.91)

(30) Priority data:
539,914 18 June 1990 (18.06.90) US

(60) Parent Application or Grant
(63) Related by Continuation
US 539,914 (CIP)
Filed on 18 June 1990 (18.06.90)

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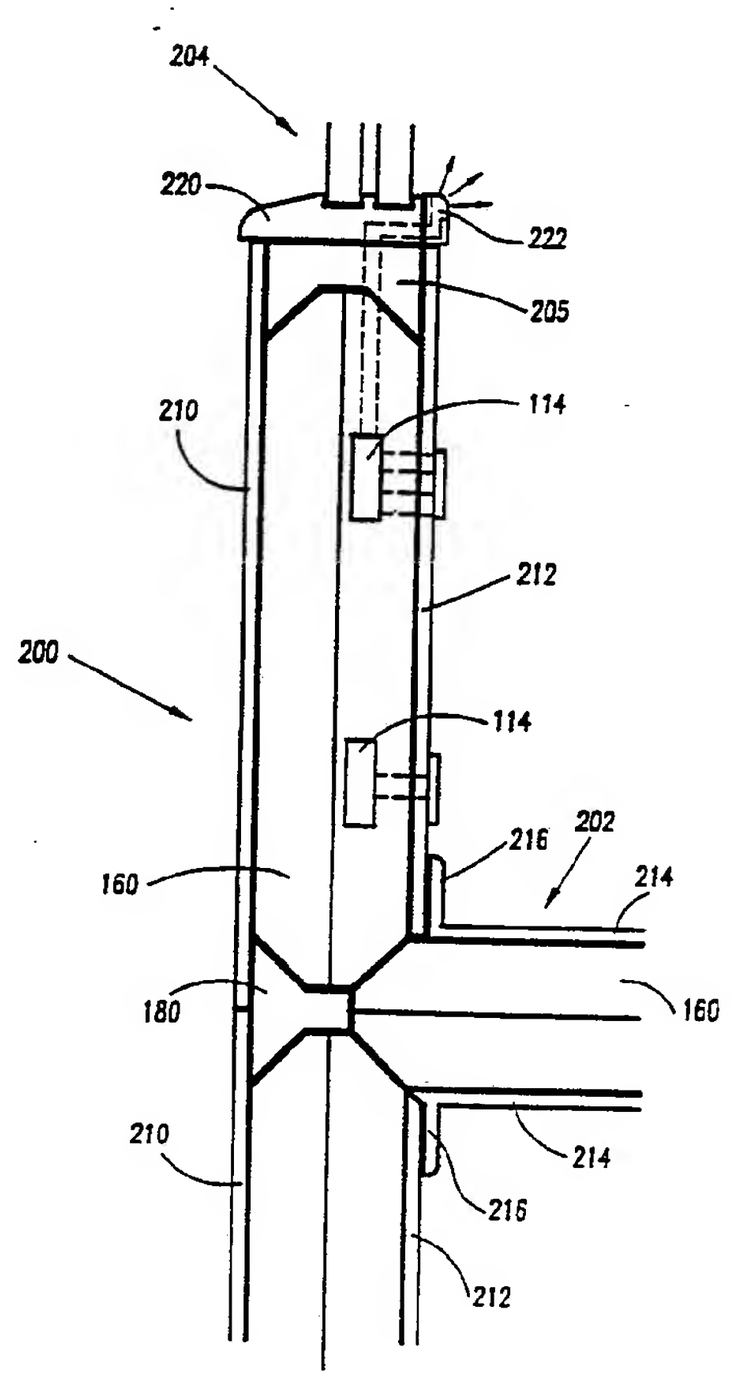
(81) Designated States: AT, AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CA, CF (OAPI patent), CG (OAPI patent), CH, CH (European patent), CI (OAPI patent), CM (OAPI patent), DE, DE (European patent), DK, DK (European patent), ES, ES (European patent), FI, FR (European patent), GA (OAPI patent), GB, GB (European patent), GN (OAPI patent), GR (European patent), HU, IT (European patent), JP, KP, KR, LK, LU, LU (European patent), MC, MG, ML (OAPI patent), MN, MR (OAPI patent), MW, NL, NL (European patent), NO, PL, RO, SD, SE, SE (European patent), SN (OAPI patent), SU, TD (OAPI patent), TG (OAPI patent), US.

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: BUILDING MATERIALS

(57) Abstract

A modular structural assembly (100) is disclosed for use in construction and for connection with other neighboring generally identical modular structural assemblies (100) to create a building structure. The modular strutural assembly (100) includes a structural subassembly having an inner volume and being mechanically connectable with the neighboring structural assemblies to define a building structure. The structural subassembly has a plurality of conduit connection apertures (110) distributed at least about the periphery thereof. The modular structural assembly also includes a utility subassembly (112) locatable within the inner volume. The utility subassembly (112) has a plurality of conduits extending from at least one junction in a plurality of directions, where the conduits are selectably connected together and locatable through the conduit connection apertures (110) for connection to corresponding utility subassemblies of the neighboring generally identical modular structural assemblies.



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BUILDING MATERIALS

FIELD OF THE INVENTION

The present invention relates to the field of mass production housing and construction systems generally and to the use of standard structural building pieces and their finishing parts in particular.

BACKGROUND OF INVENTION

Pre-fabricated building systems are common in many nations. These systems, however, often require a great deal of construction time, are expensive to assemble and use machinery at the construction site. For example, prefabricated building systems in Japan are produced using a metal frame into which pre-fabricated furnishing units and wall, floor and ceiling panels are placed in the system at the time of assembly. The finished product is a box containing all the necessary services and may be hoisted into place after lengthy and costly site transportation.

Sweden, Germany and the United States all produce the equivalent of a wood frame house with commercially available pre-cut lumber and all the fittings required for the assembly of the house on site. The foundations for these units must be of poured concrete and must include fasteners to the underside of the pre-fabricated structure.

In addition, conventional prefabricated building systems are often inflexible once the shell is assembled. As an example, all existing pre-fabricated units on the market today are connected with sealed joints and have permanent foundations.

U.S. Patents 1,307,333, 3,918,233, 3,333,383, 4,201,024, 4,250,674, PCT application WO 88/02801 and Israel Patents 18,528, 21,957, 22,455 and 30,289 describe various structural elements for prefabricated buildings.

U.S. Patents 1,307,333 and 4,393,632 describe finish panels which can be quickly attached to the interior and/or

exterior of a building.

U.S. Patent 4,250,674 and West German patent publication 3616-733-A describe structures for incorporating HVAC ducts into walls.

U.S. 4,326,012 to Charlton describes a solar cell and an associated heat duct. The solar cell is utilized to produce electrical energy which is controlled by a microprocessor.

U.S. 2,419,319 to Lankton describes a portable utility core unit which can be placed between a kitchen, a bathroom and a laundry.

U.S. 2,592,634 to Wilson describes concrete slab elements used for building.

U.S. 4,593,505 to Russel describes a panel base electrical raceway, made of plastic, for the base of a space dividing wall panel system.

U.S. 3,822,569 to Lautrup-Larsen describes a set of five different modular toy building elements.

U.S. 4,272,930 to Foster describes a modular housing system having separate wall panel, roof panel and floor panel units.

U.S. 4,275,533 to Wright describes a portable building having a floor, side walls and a roof structurally interconnected to form an integral building unit.

Soviet Union SU-601-364 to Solovev describes a portable knock/down building which has fully fitted triangular blocks forming floor-to-ceiling sections of a room. The building includes roof and floor sections also.

Soviet Union SU-1-486-576 to Oil Gas Industries describes a dismantable industrial building having struts, girders and slabs.

SUMMARY OF THE INVENTION

The present invention seeks to provide a construction system based on a number of generally small structural and non-structural members mass producible on an assembly line. The structural and non-structural members can be used as elements in all parts of a building, such as foundation, wall, floor and roof elements. In addition, the members can, if desired, include utility services, such as plumbing, electricity and air ducts.

The present invention also seeks to provide a construction process which includes the design, manufacture and production of a building using the structural members. Because the structural members can be used for all portions of a building and because they include utility services, the construction process typically involves few contractors.

The concept of an expandable dwelling unit produced by adding parts to the building structure without destroying the existing parts is a characteristic of the construction system of the present invention.

There is provided, in accordance with the present invention, a modular structural assembly for connection with other neighboring generally identical modular structural assemblies to create a building structure. The modular structural assembly includes a structural subassembly and a utility subassembly. The structural subassembly has an inner volume and is mechanically connectable with the neighboring structural assemblies to define a building structure. It also has a plurality of conduit connection apertures distributed at least about the periphery thereof. The utility subassembly is locatable within the inner volume and has a plurality of conduits extending from at least one junction in a plurality of directions. The conduits are selectably connected together and locatable through the conduit connection apertures for connection to corresponding utility subassemblies of the neighboring generally identical modular structural assemblies.

Additionally, in accordance with the present invention,

each of the conduits includes a plurality of joined conduits and the joined conduits include at least fluid conduits.

Further, in accordance with the present invention, a junction box is located in at least one junction for selectably connecting the conduits to each other. The junction box can be a multi-layer junction box located in at least one junction for selectably connecting at least the fluid conduits to each other. The fluid conduits are at least one of plumbing conduits and air conduits.

There is also provided, in accordance with the present invention, a modular structural assembly for connection with other neighboring generally identical modular structural assemblies to create a building structure. The modular structural assembly includes a structural subassembly and a utility subassembly. The structural subassembly is mechanically connectable to the neighboring structural assemblies to define the building structure. The utility subassembly is joinable to the structural subassembly and contains portions of the entirety of services necessary for the building, the portions extending in a plurality of desirable directions, thereby to provide, in conjunction with the neighboring structural assemblies, the entirety of services connected in any desired manner.

Additionally, in accordance with the present invention, the modular structural assembly includes control apparatus joinable to the structural subassembly for controlling the utility services flowing through the modular construction element. The control apparatus preferably includes a microprocessor.

Moreover, in accordance with the present invention, interior and exterior finish panels are included which are connectable to and disconnectable from the structural subassembly. The interior finish panels can be formed with utility appliances. They can also be formed with at least one piece of furniture.

Furthermore, in accordance with the present invention, energy absorbing apparatus are also included.

Still further, in accordance with the present invention, the structural subassembly is of a triangular shape.

Additionally, in accordance with the present invention, the modular structural assembly includes roofing panels connectable to and disconnectable from the structural subassembly.

Moreover, in accordance with the present invention, the structural subassembly includes insulating apparatus.

Further, in accordance with the present invention, the structural subassembly is formed of a plastic compound with additives.

Still further, in accordance with the present invention, the structural assembly can include a photovoltaic cell.

Moreover, in accordance with the present invention, the structural subassembly includes mechanical connecting apparatus for connecting together the structural assemblies and for providing structural stability. The mechanical connecting apparatus preferably snaps into the structural assemblies.

Additionally, in accordance with the present invention, the modular structural assembly also includes flat plate connector apparatus joinable to the structural subassembly. The flat plate connector apparatus can include insulation apparatus.

Further, in accordance with the present invention, the flat plate connector apparatus includes a lighting apparatus formed of a sodium impregnated sheet and a potassium impregnated sheet.

Still further, in accordance with the present invention, the flat plate connector apparatus includes an electrical circuit board.

Moreover, in accordance with the present invention, the modular structural assembly also includes sensors for measuring at least levelness, temperature, humidity and air pressure.

There is also provided, in accordance with the present invention, a building including a multiplicity of generally identical modular structural elements to be connected to each other. Each element includes a structural subassembly and a utility subassembly. The structural assembly has an inner volume and is mechanically connectable with neighboring structural assemblies to define the structure of the building. The structur-

al subassembly has a plurality of conduit connection apertures distributed at least about the periphery thereof. The utility subassembly is locatable within the inner volume and has a plurality of conduits extending from at least one junction in a plurality of directions, the conduits being selectably connected together and locatable through the conduit connection apertures for connection to corresponding utility subassemblies of the neighboring generally identical modular structural assemblies.

Additionally, in accordance with the present invention, the building includes adjustable foundation support apparatus. It also includes at least one pyramidal piece forming part of foundation support apparatus.

Further, in accordance with the present invention, the building can includes a water collection and circulation system. It preferably has a sealed roof surface formed only of flashing and counterflashing subassemblies.

Still further, in accordance with the present invention, the building is characterized in that it is generally air tight.

There is also provided, in accordance with the present invention, a supporting column including a multiplicity of generally identical modular structural elements to be connected on top of each other as in a vertical stack, each including a structural subassembly having an inner volume and being mechanically stackable and connectable with neighboring structural assemblies to define structure of the supporting column, the structural subassembly having a plurality of conduit connection apertures distributed at least about the surfaces thereof and a utility subassembly locatable within the inner volume, the utility subassembly having a plurality of conduits extending from at least one junction in a plurality of directions, the conduits being selectably connected together and locatable through the conduit connection apertures for connection to corresponding utility subassemblies of the neighboring generally identical modular structural assemblies.

There is further provided, in accordance with the

present invention, a supporting beam including a multiplicity of generally identical modular structural elements to be connected on top of each other as in an horizontal stack, each including a structural subassembly having an inner volume and being mechanically stackable and connectable with neighboring structural assemblies to define structure of the supporting beam, the structural subassembly having a plurality of conduit connection apertures distributed at least about the surfaces thereof and a utility subassembly locatable within the inner volume, the utility subassembly having a plurality of conduits extending from at least one junction in a plurality of directions, the conduits being selectably connected together and locatable through the conduit connection apertures for connection to corresponding utility subassemblies of the neighboring generally identical modular structural assemblies.

There is yet further provided, in accordance with the present invention, a removable utility subassembly connectable to other utility subassemblies including a plurality of conduits extending from at least one junction in a plurality of directions and at least one junction box located in at least one of the at least one junction for selectably connecting the plurality of conduits to each other.

There is also provided, in accordance with the present invention, a modular structural assembly for connection with other neighboring generally identical modular structural assemblies to create a surface of an existing building structure. The modular structural assembly includes a structural subassembly having an inner volume and being mechanically connectable with the neighboring structural assemblies and the existing building structure, the structural subassembly having a plurality of conduit connection apertures distributed at least about the periphery thereof and a utility subassembly locatable within the inner volume, the utility subassembly having a plurality of conduits extending from at least one junction in a plurality of directions, the conduits being selectably connected together and locatable through the conduit connection apertures for connection

to corresponding utility subassemblies of the neighboring generally identical modular structural assemblies.

Finally, there is provided, in accordance with the present invention, a window frame including a frame housing and air ventilation louvers integrally formed with the housing.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be appreciated and understood more fully from the following detailed description, taken in conjunction with the drawings in which:

Fig. 1A is an exploded isometric illustration of a structural units connected together, constructed in accordance with the present invention;

Fig. 1B is an isometric illustration of a portion of the structural unit of Fig. 1A;

Fig. 2A is a detailed isometric illustration of a flat plate connector useful in the structural unit of Fig. 1A;

Fig. 2B is a side view of the flat plate connector of Fig. 2A along lines IIB-IIB;

Fig. 3A is an isometric illustration of portions of an utility assembly useful in the structural unit of Fig. 1A;

Fig. 3B is a top view sectional illustration of a junction box of the utility assembly of Fig. 3A;

Fig. 4 is an exploded isometric illustration of an alternative embodiment of the structural unit of Fig. 1A;

Fig. 5A is a side view sectional illustration of the connection of two structural units of Fig. 1A in a line;

Fig. 5B is an illustration of the connection of a multiplicity of the structural units of Fig. 1A in a stacked configuration;

Fig. 5C is a side view sectional illustration of the connection of two structural units of Fig. 4 in a line;

Fig. 5D is an illustration of the connection of a multiplicity of the structural units of Fig. 4 in a stacked configuration;

Fig. 6 is a schematic illustration of a multiplicity of the structural units of Fig. 4 connected together to form walls, baseboards, windows and doors, respectively;

Figs. 7A and 7B are schematic illustrations of two methods of attaching plumbing fixtures to a multiplicity of structural units of Fig. 1A;

Fig. 7C is a schematic illustration of a rigid sleeve connection useful for connecting plumbing or other utilities to the utility assembly of Fig. 3A;

Fig. 8 is a schematic illustration of a piece of furniture attached to a multiplicity of structural units of Fig. 1A;

Fig. 9A is a pictorial illustration of a door, walls and floor constructed from the structural units of Fig. 1A;

Fig. 9B is a top view sectional illustration of a door;

Figs. 10A and 10B are schematic illustrations of a multiplicity of many-shaped structural units of Fig. 1A combined to form a sloped and a flat roof, respectively;

Fig. 11A is a schematic illustration of structural units utilized for foundation elements placed in the ground;

Fig. 11B is a schematic illustration of structural units utilized for foundation elements placed on the ground;

Fig. 11C is a schematic illustration of structural units forming a foundation piling;

Fig. 12A is a schematic illustration of a house utilizing different lengths of the foundation elements of Figs. 11A or 11B to form a level house on non-level ground;

Fig. 12B is a schematic illustration of a building built with the structural units of the present invention and located on the side of a hill;

Figs. 13A, 13B and 13C illustrate a multiplicity of shapes which can be built from the structural units of the present invention;

Fig. 14 is a schematic illustration of a planar surface formed of a multiplicity of structural units of Fig. 4, seen from the top; and

Figs. 15A and 15B are isometric illustrations of connectors used in the embodiment of Fig. 14.

DESCRIPTION OF THE PRESENT INVENTION

Reference is now made to Fig. 1A which illustrates a structural unit 100 of the present invention which can be utilized as a portion of any structural element of a building, such as walls, floors, and ceilings, as well as their adaptive finishes.

Structural unit 100 typically comprises two outer housing layers 102 between which is sandwiched a flat plate connector 104. Each layer 102 is typically comprised of two, typically triangular, sections 106 connected together by a T-connector 108, which, additionally, is operative to provide strength to layers 102. T-connector 108 is described in more detail hereinbelow with respect to Fig. 5A. Flat plate connector 104 is also typically built from two typically triangular pieces 105. Both the sections 106 and the flat plate connector 104 can be of non-triangular shapes, such as rectangles or squares

The layers 102 and flat plate connector 104 can also be formed in other, non-triangular shapes as desired.

Typically, housing layers 102 also include upturned edges 107, useful for connecting structural units 100 together and for connecting finish panels to the units 100, as shown in Figs. 5A and 5C.

Outer housing layers 102 are preferably composed of a carbon chain plastic material such as a thermoplastic engineering resin, Butyl, a thermoplastic pultruded material, or any other material which provides suitable strength, rigidity, and has lightweight properties. The material chosen should have considerable compression and tensile strengths so as to distribute the live and dead loads of a building structure in which they are used. In addition, the material should be fairly lightweight for ease of use during construction without heavy site machinery.

Structural unit 100 typically includes several openings 110 through which utilities, such as conduits, can be run. Openings 110 are provided in structural unit 100 both on the edges and throughout the body of each layer 102 and 104 to provide

maximum flexibility for utility runs. The openings 110 are placed in order to provide for at least ninety, sixty and forty five degree angle turns for the utilities within a completely assembled building planar surface, such as a wall, floor or ceiling.

Typically, utility services for a building, such as plumbing, electricity and HVAC, are provided by a utility assembly 112, located in at least one structural unit 100, comprised of ducts 113 and junction boxes 114, shown in more detail in Figs. 3A and 3B. The junction boxes 114 direct the flow of the utility services. Thus, the direction of the utility services can be changed at any structural unit 100 which has a junction box 114.

When a plurality of structural units 100 are combined together to form a planar surface, the utility assemblies 112 are combined together to form a full utility surface. The ducts 113 are connected to other ducts 113 in other structural units 100 via slip connectors 115, similar to garden hose plastic connectors such as those manufactured by Plasson.

The utility assembly 112 can be pre-formed or fused into one or both of outer housing layers 102 during manufacture. In accordance with an alternative embodiment of the present invention, the utility assembly 112 is placed in the housing layers 112 during construction of the building and can be removed, rerouted and/or replaced at any time.

The utility assembly 112 is formed of a number of units having one of two basic shapes. The units are an L-shaped unit 116 and a straight unit 118. The junction boxes 114 of the L-shaped units 116 can selectively change the direction of flow of the utility services, either horizontally in the plane of layers 102 or vertically between the layers 102 and those of the straight units 118 either stop the flow, enable it to continue flowing straight, or enable it to flow vertically between layers 102. Alternatively, if no change in direction is desired, straight units 118 can be formed without a junction box 114.

The ducts 113 are typically formed of a plurality of

layers, typically at least one layer each for plumbing, electricity and HVAC services, and the junction boxes 114 are typically multi-layer switches. Alternatively, the ducts 113 and junction boxes 114 can be of only one layer.

Included in the utility assembly 112 are connectors 119 for connecting the utility assembly to external utility elements, such as plumbing or other fixtures, shown and described in more detail hereinbelow with reference to Figs 7A and 7B.

It will be appreciated that the utility assembly 112 can be utilized in an existing building without the outer layers 102 or the flat plate connector 104. When used in this manner, the utility assembly 112 provides easily removable and reroutable utility runs.

Alternatively, the utility services can comprise hand fed pipes 120, as shown in Fig. 1B to which reference is briefly made. In this alternative embodiment, of which only one layer 102 is shown, the hand fed pipes 120 are typically larger than the structural unit 100 and thus, are fed through a multiplicity of units 100.

Reference is now made to Figs. 2A and 2B which detail the flat plate connector 104.

The flat plate connector 104 is operative for connecting electrical utilities, for insulating the unit 100, for aligning housing layers 102 in a parallel fashion and for anchoring layers 102 to each other. During the fabrication of the structural unit 100, the flat plate connector 104 is placed between housing layers 102. If desired, the elements 102 and 104 can then be fused together, thereby completely sealing in the flat plate connector 104.

The flat plate connector 104 is maintained, once the structural unit 100 is in a building structure, through the opening and/or replacing of a given structural unit 100.

As shown in Fig. 2B, connector 104 comprises four layers 132, 134, 136 and 138 located inside a housing 130, typically formed of a suitably strong, rigid and lightweight material, such as plastic.

The connector 104 preferably doubles as a power source and as such, layers 132 and 134 are preferably comprised of a hard material, such as a plastic polymeric compound, in which is respectively impregnated zinc, potassium and sodium.

Since sodium has a high absorption and radiant capacity and potassium has properties of emitting light and energy when heated, as by the sodium impregnated layer 134, the connector 104 typically can convert cumulative solar heat energy into radiant interior heat of a building structure and into energy useful for lighting and for providing the power needs of a building structure. Such an energy converter is known as a hybrid battery or a zinc-air battery, and is described in the article, "Improving Batteries: Major Hurdles," The New York Times, June 14, 1989, p. D7. The properties of the sodium and potassium energy exchange are also described in The Encyclopedia Brittanica, Special 50th Edition, published in 1980, under the headings "Potassium" and "Sodium".

The chemical reaction between the layers 132 and 134 creates heat, light and electrical energy which is stored in the housing 130, or in an external storage unit (not shown) for use for lights and other power needs as described hereinabove. There typically are no wires; instead, a prepositioned terminal connection 140 connects the layers 132 and 134 to the electrical duct of the utility assembly 112.

A connector 104 as described is useful for sites with no utilities. The connector 104insulates and stores energy received by the building from sunlight and from other environmentally-generated energy sources, such as wind and rain. The ability to store heat enables a building formed of the units 100 of the present invention the ability and potential to be energy self sufficient at a site with no utility hook-up. It also provides an augmented energy source.

Layer 136 is optional and is typically a pre-wired circuit board sandwiched between layers 132 and 134. It may comprise an electrical network and a microprocessor 142, such as an Intel N-10 chip and typically including a minimum memory

capacity of 2 megabytes, and a memory 144 for storing data regarding the flow of utility services through the structural building unit 100.

Memory 144 is preferably pre-programmed with information regarding the physical properties of the structural building unit 100 in which it resides. For example, if a structural unit 100 is part of a building comprising flat planar surfaces, such as walls, memory 144 may contain pre-programmed information regarding the desired temperature level of the room where it will be placed as well as acceptable stress and strain levels for the unit 100. Memory 144 may contain pre-programmed information regarding the desired direction, height and position of the structural unit 100 needed to produce a level building. It typically also contains information about user-modified utility services connections between it and its adjacent units 100.

The flat plate connector 104 has terminal connections 146 by which it connects, through corresponding terminal connections 146 in layers 102 and in T-connector 108, to corresponding flat plate connectors 104 in adjacent units 100. In this manner, a grid of microprocessors 142 and memories 144 can be defined.

Layer 138 is typically an optional insulation layer formed of a housing of expanded polystyrene with an ABS structural additive surrounding an inner space 139 in which a near vacuum is maintained.

At pre-defined places in an assembled room of a building being built, such as at a baseboard, floor piece, window or door frame or along a planar surface unit, such as a wall, computer plugs 148 (Fig. 9A) are placed for connection to a computer (not shown), such as a personal computer. Networking software in the computer, similar in function to the Computer Integrated Manufacturing program produced by IBM, enables the registration of all structural building units 100 connected as a planar surface as one unit where each structural unit 100 acts as an independent network station capable of receiving and transmitting information.

Microprocessor 142 and memory 144 can also be used to

store and display, on the personal computer, assembly instructions for a whole completed structural assembly, such as a wall or a room. The instructions and structural information are transmitted through connections 146 and are available to the computer via computer plug 148. Although not required, structural information can be received and transferred as each unit 100 is connected to an existing structure of structural units 100, causing the planar surface being built to be registered by the computer software as a single, solid surface.

In accordance with the present invention, a finished building is broken up by the software into zones, such as rooms, to communicate HVAC and maintenance information to the user of the personal computer mentioned above. The software operates in a manner similar to the operation of a Variable Air Control (VAC) system such as exists in prior art HVAC air handling systems.

A set of sensors 122, shown in Fig. 1A, for sensing at least levelness, temperature, humidity, and air pressure are included in each structural unit 100. When a set of structural units 100 are registered as a wall in a room, typically a minimum of two sensors 122 of a given type near the wall and floor surface and two sensors 122 of the same type near the ceiling surface are enabled. The remaining sensors 122 of the given type in the wall, floor and ceiling of the room are disabled, typically via the networking software which is custom programmed to the desires of the people who use the room.

The sensors 122 for levelness located in floor and ceiling planar surfaces are utilized to verify the levelness of the building structure before the installation of finish panels.

Other sensors can be included in sensors 122 for detecting cracks, leaks, utility malfunctions, and fire. Additionally, pressure and stress and/or strain sensors can be included as can standard sensors used in building maintenance systems.

Through microprocessors 142 and the building maintenance sensors of sensors 122, the computer is able to detect the functioning of the building's electrical, plumbing, and HVAC systems. Through the sensors 122, the computer is able to dif-

ferentially control the environment throughout the building. Typically, a manual override is included as is a detection capability of various types of system failures.

Reference is now made to Figs. 3A and 3B which illustrate a multi-layer junction box 114 in isometric cut section and top view sectional illustrations, respectively. Shown in Figs. 3A and 3B are ducts 113 comprising a multiplicity of ducts 150, one each for each type of utility service.

Multi-layer junction box 114 is a cylindrical unit which comprises a removable cover layer 151 in which is a recessed multi-layer knob 152, such as are used for controlling the tone, volume and balance of a radio, for individual selection of the locations of a plurality of blades 154. The blades 154 typically have a number of alternative locations, as shown in Fig. 3B, and are operative to change the direction of flow of the utility service by either 90^{o} or 0^{o}.

If desired, a plug 155 can be placed in place of one of the ducts 113 to stop the flow of services in the plugged direction.

Rubber gaskets 156 are located along the edges of junction box 114 to provide a tight seal between the blades 154 of the junction box 114 and the ducts 113 during and after motion of the blades 154.

It will be appreciated that junction boxes 114 can be designed to allow the vertical flow of services rather than the horizontal flow as shown in Figs. 4A and 4B. By 'vertical flow', it is meant flow between outer housing layers 102. To provide vertical flow, the junction boxes 114 have only one layer (i.e. they are operative for only one utility service) and no blades 154. The input is from the top, where the removable cover layer 151 is located, to the bottom of the junction box 114.

The junction boxes 114 are typically manually operated or they can be automatically operated, typically via electrical means such as a computer controlled mechanical damper. Alternatively, for locations without electricity, a vacuum or magnetic force can be used to change the positions of the junction boxes

114.

Reference is now made to Fig. 4 which illustrates an alternate embodiment, labeled 160, of the structural unit 100. Similar to structural unit 100, structural unit 160 comprises two outer housing units 162 with a flat plate connector 104 sandwiched in between layers 162.

In accordance with this alternate embodiment, outer housing layers 162 have angled edges 164 and flat upturned edges 166. Layers 162 also have angled sockets 168 forming part of a snap joint, similar to a dovetail joint, which are described in more detail hereinbelow with respect to Figs. 5A and 5C.

It will be appreciated that upturned edges 107 (Fig. 1A) and sockets 168 (Fig. 4) facilitate the joining of two or more structural units 100, via bolting and/or snapping, respectively. upturned edges 107 and indentations 168 also facilitate the joining of a structural building unit 100 with prospective finish panels.

Reference is now made to Figs. 5A, 5B, 5C and 5D. Figs. 5A and 5B respectively illustrate the horizontal and vertical connection together of structural units 100. Figs. 5C and 5D respectively illustrate the horizontal and vertical connection together of structural units 160.

To connect two structural units 100 together, two T-connectors 108 are placed in a recessed manner between them, lying on upturned edges 107. The entire structure is bolted with bolts 172 which typically comprises a gasket typically of NEOPRENE, and a washer. It will be appreciated that NEOPRENE is preferably utilized to enable the joints to expand and contract as necessary.

T-connectors 108, which are also used to connect together two sections 106 (Fig. 1A), are formed of any suitable material, such as thermoengineering plastic, metal, steel, aluminum or wood. They include a socket 174, forming part of a snap joint, into which a fin 176 on a finish panel 175 is placed. Fin 176 and socket 174 together form the snap joint which is utilized throughout the present invention to provide a relatively quick,

simple and generally boltless connection method.

A pressing action locks the finish panels 175 in place. Typically the finish panels 175 are released via a push and twist action. This enables the structural unit 100 to be easily accessed.

Other suitable techniques for connecting the structural building units 100 together and to the interior and exterior finish panels 175 can be employed and are known to persons of ordinary skill in the art.

Fig. 5C shows the connection of three structural units 160. To connect together two structural units 160, a Y-connector 180 is utilized, which is also utilized to connect together the two halves of outer housing layers 162. Y-connector 180 is similar in function to T-connector 108 and can be composed of similar materials; however, it typically connects the two structural units 160 together via a plurality of snap joints formed of fins 182 and sockets 168. If it is desired, bolts 184 can optionally be included to add strength to the snap joint. Furthermore, a motor 186 can be utilized to tighten the bolts 184.

An isometric illustration of Y-connector 180 is shown in Fig. 15A and illustrates the bolt holes.

As in the embodiment of Fig. 5A, snap joints are also utilized to connect the Y-connector 180 and the flat upturned edges 166 to a finish panel 175.

To connect a third structural unit 160 to the connection of two units 160, bolts 187 which are formed with Y-connector 180 can optionally be used. If it is desired, bolts 187 can be utilized with motors (not shown). In Fig. 5C it would appear that bolts 187 and 184 intersect. In reality, they cross-over one another.

To connect four units 160 in a star formation, no Y-connectors 180 are used. Instead, bolts 184 are 187 are alternatively used.

As shown in Figs. 5A and 5C, structural units 100 and 160 can be covered on both sides with finish panels 175, which can be wall finish panels, floor finish panels or exterior finish

panels. The type of finish panel 175 attached to the unit 100 depends on the function of the structural unit 100 in the building being built. For each type of finish panel, the surface texture, material, color and finish can all be selected.

Figs. 5B and 5D respectively illustrate the vertical connection of structural units 100 and 160. The connection, in both embodiments, is typically via bolts 178. Bolts 178 typically are threaded through upturned edges 107 and 166, respectively. Alternatively, the connection is a snap connection.

In the embodiment of Fig. 5D, delta connectors 179 snap into place between the structural units 160, providing additional connection strength as well as a flat outer surface.

It will be appreciated that the structural units 100 and 160 can be vertically or horizontally combined to form columns or beams. Additionally, they can be combined end-on-end to form a waffle slab.

Reference is now made to Fig. 6 which illustrates the connection of a multiplicity of finish panels onto a wall 200, a floor 202 and near a window 204. The finish panels comprise exterior panels 210, interior wall panels 212 and floor and ceiling panels 214. In this and the remaining figures, the structural unit shown in unit 160 of Fig. 4. It will be appreciated that this is for illustration only.

Exterior panels 210 are preferably a conglomerate material reflecting the exterior design and desired aesthetic style of the building. For example, the material may be an acrylic base with an applied stone aggregate and or a rubber base with a phenolic coating or other material with equivalent or similar properties.

The interior wall finish panels 212 are preferably of a solid material, such as gypsum in a PVC frame or such as papered foam polyethylene. Other materials, such as wood, may be used and are chosen to reflect the interior design. For example, the wall finish panel 212 may come complete with an enameled finish and/or a papered textured pattern. If the wall finish panel 212 is to contain furniture or an appliance, these can be easily

connected to the basic structural units 160. Examples of this are shown in Figs. 7A, 7B and 8, described in more detail hereinbelow.

It will be noted that all materials of the finish panels have a 2 hour minimum fire rating and class A flame spread. Additionally, finish panels 175 can be formed with an internal vacuum (not shown) to conform to the dimensions and add to the BTU exchange value of the vacuum layer 138 (Fig. 2B) of flat plate connector 104.

Additionally, baseboard finish pieces 216, typically integrally formed with the floor finish panel and ceiling cove moldings integrally formed with the ceiling finish panel 214, are connected as an interior finish piece to structural building unit 160.

As can be seen in Fig. 6, a window frame 220, which surrounds window 204, via a specially shaped connector 205 to the wall. Frame 220 is formed as a single extruded assembly and typically includes an air ventilation louver 222 connectable to utility assembly 112, described in more detail hereinbelow.

The present invention can be utilized to build structures such as a column, beam, bridge, or highway. In these embodiments, structural units 160 are utilized without utility assemblies 112.

For all embodiments of the present invention, electrical wiring, duct runs and all computer connections are typically snapped into a surface planar unit after its registration as a single unit. When the surface planar unit is registered as a single unit, the utility arrangement will be available to the computer. At that point, the computer typically signals the junction boxes 114 of the surface planar unit to enable or disable some of the possible connections. This routing and switching by electrical current is accomplished through the assistance of routing software similar to existing railroad tracking and switching software utilized in train yards.

Reference is now made to Figs. 7A, 7B, and 7C. In accordance with the present invention, plumbing fixtures, such as

sinks 230, faucets 232 and plumbing pipes 233, are typically connected to a structural building unit 160 either with the plumbing connectors 234 (Fig. 7B) integrally formed with interior finish panels 212 or the fixtures are integrally formed on interior finish panels 212. (Fig. 7A). Any fixture which carries water, such as pipes 233 and faucet 232, is typically connected to the closest junction box 114, through finish panel 212.

Plumbing connectors 234 are typically utilized for connecting commercially available plumbing fixtures to the structural units 160 of the present invention. Plumbing connectors 234 are made to the dimensions of existing fixtures so as to bracket them completely.

Fig. 7C illustrates the connection of a conduit or vent fixture 240 to junction box 114 via a ridged threaded sleeve connection 242. Ridged threaded sleeve connection 242 has ridges and threads 244 to enable a tight connection between element 240 and junction box 114. It will be appreciated that the connection shown in Fig. 7C is utilized for connecting all kinds of ductwork to the interior or exterior wall surface of the building. Typically, a washer 246 is also utilized around the element 240 for sealing the element 240 to wall 212.

Other kinds of connectors can alternatively be used, as will be known to one skilled in the art.

Routing of flow in the conduits of a building with or without connected utility assemblies 112 may be accomplished via plumbing software in the computer. The operator, typically the person building the building or a pre-designed program, provides information to the computer as to the location of plumbing fixtures within a room and as to the location of the room in which they reside. From this information, the plumbing software can rout the flow in the conduits after the planar surface is constructed. The plumbing software is typically a combination of AUTOCAD, manufactured by Autodesk Inc. of Sausalito, California of the U.S.A., and an animation program, similar to WALKTHRU manufactured by Bechtel of the USA, which is adapted to a format compatible with personal computers.

Reference is now made to Fig. 8. In accordance with the present invention, furniture elements can be integrally formed with one or more interior wall finish panels 212. Shown in Fig. 8 is a chest 250 of drawers 252. The chest 250 is integrally formed with two wall panels 212 and the whole unit is connected to structural units 160 via hooks 254 which hook into upturned edges 166. It will be appreciated that hooks 254 require no extra elements, such as bolts, to connect them to units 160. However, bolts can be utilized if necessary.

Similarly, a computer can be integrally formed with interior wall finish panel 212 and can be connected to the electric run of utility assembly 112 via threaded ridged sleeve connection 242 (Fig. 7C). The computer is shown in Fig. 9A.

As can be seen in Fig. 6, air conditioning and heating louvers 260 can be included in wall finish panel 212. They are connected to utility assembly 112 in a manner similar to that shown in Fig. 7C for pipe 240.

Reference is now made to Fig. 9A which illustrates a wall 270 and a doorway 272.

In accordance with the present invention, window frames 220 (Fig. 6), and door frames 274 may include venting access louvers 222 (Fig. 6) which connect, in a manner similar to that shown in Fig. 7C, to the utility assembly 112. Pre-designed dimension-stable sections, such as the abovementioned window frames 220 and door frames 274, can be provided with the louvers 222 in place. As is known in the art, a "dimension-stable" section is one which is non-shrinkable and will not deteriorate. Typical dimension-stable materials are plastic polystyrene with additives, treated wood floors, or coated metals.

The flow of air conditioning and heating through connected utility assemblies 114 of a building can be directed by software similar to that of the plumbing and electrical systems, such as a railroad track and switching system. Alternatively, it can be directed by manually selecting the positions of the blades 154 (Figs. 3A and 3B).

Electrical outlets 276 are pre-assembled in certain

dimension-stable sections in finish pieces 175. Switches 278 can be pre-assembled in door frames 274 and in water resistant window frames 220 (not shown).

As mentioned hereinabove, a computer 280 can also be formed or pre-assembled into a wall finish panel. If desired, computer 280 can be used to assist in the assembly of the building.

The doorway 274 typically is formed of a doorframe 282 typically formed of a single piece of extrusion polyvinylchloride (PVC) and is typically formed with fins (not shown) in order to snap into structural units 160 as described hereinabove with respect to the finish panels 175. The lintel 284 is typically of solid, reinforced Butyl or other similar material as required by the design specifications of the building.

Fig. 9B, to which reference is now made, is a section of the doorway 272 of Fig. 9A in which a door 280 is located. Door 280 is connected to the two halves of wall 270 via door assembly units 282 which connect to the structural units 160 of wall 270 via snap joints 284. One of the assembly units 282 includes at least one cylindrical hinge 286.

From the preceding description, it is apparent how the structural units 160 can be used to facilitate the construction of buildings and other structures. Because of their lightweight modularity, the structural units 160 can be connected together by a minimum of one or two people to form a desired building structure, without the aid of heavy site machinery.

In addition, the building structure can be easily modified after the building has been finished in order to change the size, shape or even style of the building structure or to modify its design. This is achievable by dismantling and reconnecting structural units 160 at a new location. By dismantling a building built of structural units 160, valuable real estate property can be regained without the destruction of the property.

Reference is now made to Figs. 10A and 10B which illustrate the construction of a sloped and a flat roof, respectively, using structural units 160 of the present invention.

To construct a sloped roof, structural units which are sloped and of other shapes, all labeled 300, are utilized in addition to structural units 160. At least some of structural units 300 include protrusions 302 for connecting units 300 to shingles 305 which fit onto units 300 in an overlapping manner.

In addition, corner connectors 304 are utilized to connect together structural units 160 at a corner of the building. Corner connectors 304 are similar to Y connectors 180 in function; however, corner connectors 304 have the shape shown in Fig. 10A and are similar in function to delta connectors 179 (Fig. 5D).

Shingles 305 are extruded shapes overlapping in a horizontal fashion. They are preferably of blow molded engineering resins, such as polyethylene foam in an ABS shell, and include insulation as well as energy absorbent sodium. The energy absorbent sodium is operative to store heat and to provide radiated light when needed at interior locations of the building, as mentioned hereinabove with reference to flat plate connector 104.

An edge shingle 306, comprising a water collection gutter 307, is typically included thereby to finish the shingling of the roof and to provide water collection.

If desired, photovoltaic cells 308 can be included on shingles 305 for collecting solar energy.

Fig. 10B illustrates the construction of a flat roof with an optional solar water collection and circulation system. Three structural units 160 are connected together, as shown, to form a roof parapet 320. The roof itself is comprised of flashing pieces 322, formed of pultruded butyl/ABS coated with TEDLAR, an anti-ultraviolet coating, connected to counterflashing pieces 324 formed of the same material as the flashing pieces 322. The flashing 322 and counterflashing pieces 324 eliminate any need for conventional tarring or for the use of a fiberglass matte sandwiched in tar or any layering over a permeable roof surface. Photovoltaic cells 308 can also be placed on the top edge of flashing pieces 490.

Shown in Fig. 10B is a solar water collection and

circulation system. Water is collected on the roof into a solar pond 330 and feeds into an overflow collecting pipe 332 for collecting the water which exceeds an allowed height. The water 330 which remains on the roof is useful for heating and cooling the building.

Collecting pipe 332 feeds into a junction box 334 which is, in turn, connected to a second collecting pipe 336. Collecting pipe 336, formed in a second external panel 338 on the exterior of the building, brings the water to the outside of the building and enables the water to drip down along the perimeter of the building. At a location below the floor of the building and along the side of the building, is a water collector 340, typically integrally formed with the external finish piece 339, into which the water drips.

From the water collector 340, the water is pumped, via pump 342 and pipes 344, through the utility system of the building to a pipe 346 spilling above the water level on the roof and back to the pond 330.

Due to the overlapping of the shingles 305 or, for a flat roof building, the flashing and counterflashing pieces 490 and 495, respectively, the present invention is inherently waterproof and, in conjunction with the sealing provided by the exterior finish pieces, provides a sealed, airtight container assembly when finished. If necessary, the constructed building can be pressurized, such as might be required for a building constructed on a planetary surface such as the surface of the Moon or free floating in an orbit or trajectory in space.

Upon pressurization, the interior finish panels 212, which for this embodiment have rubberized edges, press upon one another, making an airtight seal. The strength of the airtight seal is typically monitored by sensors 122.

It will be appreciated that the present invention affects a savings in utilities and heat loss due to the circulation of storage water in the surface planar unit and on the roof.

Reference is now made to Figs. 11A and 11B which illus-

trate structural elements for foundations of a building and to Fig. 11C which illustrates a foundation piling formed of structural elements of the present invention.

In accordance with a preferred embodiment of the present invention, concrete foundations are not necessary for a building. Foundation structural units, marked 400, are typically formed in the shape of footings and may be placed in appropriately dug trenches 402 or above the ground level.

It will be appreciated that each foundation unit 400 is formed of a connection support piece 406, two side support pieces 408 and two feet 410, typically formed of a multiplicity of elements 412. The connection support piece 406 is typically integrally formed with a Y-connector 180 and is connected to the two side support pieces 408 typically via a motorized bolt 412 system as described hereinabove. The weight of the building structure is supported through the bending of the connection support piece 406 against the two side support pieces 408 which is counteracted by the two feet 410.

The location of the connection support piece 406 with respect to the two side support pieces 408 can be adjusted, either manually or electrically, so as to change the height of the building. Typically this is done before the floor of the building is connected together and when it is desired to level the floor. To effect the adjustment, connection support piece 406 comprises an oval hole (not shown) which facilitates a sliding action of typically a pultrusion (not shown) of the connection support piece 406.

If the adjustment is automatically performed, the leveling sensors of sensors 122 measure the distance of each structural unit 160 to the ground. As a result of the measurement, the motorized bolts 412 are activated to either pull the support pieces 408 towards each other, to raise the building, or to push them away from each other, to lower the building.

In order to form the foundation of the building structure, the trench 402 can be dug into which the footings 410 are placed. Earth is then placed against or covering the

footings 410 thereby anchoring them in place.

Alternatively, a pointed tripodal leg 420 can be utilized in place of footings 410, as shown in Fig. 11B. The remaining elements of foundation units 400 remain the same.

Alternatively, as shown in Fig. 11C, structural units 160 may be vertically connected to form a piling 450 to be placed into an already dug anchoring hole. The piling 450 is comprised of a multiplicity of structural units 452 having decreasing size and a piling end piece 454 which is pointed, so as to facilitate the hand-driving of the piling into its hole by a hammer and mallet. This typically requires an effort on behalf of the builder similar to that of bolting railroad tracks to the wood beneath.

It will be appreciated that conditions of planetary surfaces may preclude the need for digging anchoring holes. The dead weight of the completed structure and the prevailing weather conditions typically determine the depth and shape of the predesigned footings and pilings for the particular structure.

Reference is now made to Figs. 12A and 12B which illustrate two completed buildings fashioned from a multiplicity of structural building units 160

It may be desired to place a completed building 460 at an elevation above the ground, typically with steps leading up to a front entrance. Such a completed building 460, without the steps, is shown in Fig. 12A coupled to pilings 462 and in Fig. 12B coupled to foundation legs 464. If necessary, tie downs 4668 may be used due to local wind loads.

In the building in Fig. 12B, foundation legs 464, with either footings 410 or pointed tripodal legs 420, may be short enough to allow the completed structure to sit directly on the ground. To do so, legs 464 are of differing lengths in order to follow the shape of the site terrain, in a manner similar to that used to build a structure standing on columns. In this manner, costly site digging and leveling is not necessary.

The differing lengths of the legs enable the leveling of the building and are determined based on the levelness of the

building measured by the leveling sensors 122 or by manually measuring the distance from the tops of the legs 464 to the ground.

As mentioned hereinabove, the lengths of the legs 464 can be changed by changing the position of the connection support piece 406 with respect to the side support pieces 408. The levelness of the building can be manually evaluated or it can be evaluated through the operation of software, such as a combination of the Bechtel animation WALKTHRU and 3DM programs, during the construction and erection of the building structure.

Reference is now made to Figs. 13A, 13B and 13C which illustrate other structural forms possible with the structural units of the present invention. These other forms may include, but are not limited to, circular forms 480, polygonal forms 482 and morphological forms 484. The structural units from which these forms are produced are typically of a not-necessarily square or triangular shape. For the circular form 480, the structural units are of an arcuate shape. For the polygonal and morphological forms 482 and 484, the structural units are of triangular and square or rectangular shapes.

A software design program, such as the Bechtel animation WALKTHRU program combined with AUTOCAD, is typically used to design the building structure to be built. It typically enables the operator, through animation, to see the building before and during construction by "walking through" it. Once the operator has decided on a design, the program generates a list of the different shaped structural building units 160 needed to construct the building. The generated list is typically then sent to a manufacturing facility.

Reference is now made to Fig. 14 which provides a schematic structural elevation view of a planar surface formed of a multiplicity of the structural units 160 of the present invention and to Figs. 15A and 15B which illustrate elements of the planar surface of Fig. 14.

Fig. 14 is an elevation of a surface formed of four structural units 160 connected together via Y-connectors 180

along sides 500 of units 160 and corner connectors 502 connecting the corners of four units 160.

Y-connectors 180 and corner connectors 502 are formed with typically squared indentations 504 which, when two connectors are placed next to each other, form openings 506, similar to openings 110 (Fig. 1A), through which ducts 113 and junction boxes 114 of utility assembly 112 can extend.

Fig. 15A is an isometric view of the Y-connector 180. Since Y-connector 180 has been described in detail hereinabove, in the interests of conciseness, the description will not be repeated herein.

Fig. 15B is an isometric view of corner connector 502. Corner connector 502 is typically the intersection of four Y-connectors 180 which have already been described hereinabove.

It will be appreciated that both the Y-connector 180 and the corner connector 502 add structural stability to a building formed in accordance with the present invention, particularly during the construction and dismantling stages.

As will be apparent to persons skilled in this art, different modifications and variations can be made in this invention without departing from the spirit or scope of the invention. The embodiment shown in this invention is merely an example. For example, the structural units 100 and 160 may be used as columns or piles, or for long and short span members adapted to be used for highway, bridge, or tunnel construction.

Furthermore, the structural units 100 and 160 can be utilized, in conjunction with the finish panels 175, for interior or exterior sheathing for conventional existing buildings.

Both rigid systems and flexible column pipe extrusions may be made available for this construction system in accordance with the invention. The invention typically also conforms to earthquake building codes.

Because the invention in its broader aspects is not limited to specific details, representative methods and apparatus, and illustrative examples shown and described, departure may be made from such details without departing from

the spirit or scope of the general inventive concept.

CLAIMS

1. A modular structural assembly for connection with other neighboring generally identical modular structural assemblies to create a building structure, the modular structural assembly comprising:

a structural subassembly having an inner volume and being mechanically connectable with said neighboring structural assemblies to define a building structure, said structural subassembly having a plurality of conduit connection apertures distributed at least about the periphery thereof; and

a utility subassembly locatable within said inner volume, said utility subassembly having a plurality of conduits extending from at least one junction in a plurality of directions, said conduits being selectably connected together and locatable through said conduit connection apertures for connection to corresponding utility subassemblies of said neighboring generally identical modular structural assemblies.

2. A modular structural assembly according to claim 1 and wherein each of said conduits comprises a plurality of joined conduits and said joined conduits comprise at least fluid conduits.

3. A modular structural assembly according to claim 1 and including a junction box located in at least one junction for selectably connecting said conduits to each other.

4. A modular structural assembly according to claim 2 and including a multi-layer junction box located in at least one junction for selectably connecting at least said fluid conduits to each other.

5. A modular structural assembly according to claim 2 and wherein said fluid conduits are at least one of plumbing conduits

and air conduits.

6. A modular structural assembly for connection with other neighboring generally identical modular structural assemblies to create a building structure, the modular structural assembly comprising:

a structural subassembly mechanically connectable to said neighboring structural assemblies to define said building structure; and

a utility subassembly joinable to said structural subassembly and containing portions of the entirety of services necessary for said building, said portions extending in a plurality of desirable directions, thereby to provide, in conjunction with said neighboring structural assemblies, the entirety of services connected in any desired manner.

7. A modular structural assembly according to claim 1 and including control means joinable to said structural subassembly for controlling said utility services flowing through said modular construction element.

8. A modular structural assembly according to claim 7 and wherein said control means includes a microprocessor.

9. A modular structural element according to claim 1 and including interior and exterior finish panels connectable to and disconnectable from said structural subassembly.

10. A modular structural element according to claim 1 and also including energy absorbing means.

11. A modular structural element according to claim 1 and wherein said structural subassembly is of a triangular shape.

12. A modular structural element according to claim 1 and

including roofing panels connectable to and disconnectable from said structural subassembly.

13. A modular structural element according to claim 9 and wherein said interior finish panels are formed with utility appliances.

14. A modular structural element according to claim 1 and wherein said structural subassembly includes insulating means.

15. A modular structural element according to claim 9 and wherein said interior finish panels are formed with at least one piece of furniture.

16. A modular structural element according to claim 1 wherein said structural subassembly is formed of a plastic compound with additives.

17. A modular structural element according to claim 1 and including a photovoltaic cell.

18. A modular structural assembly according to claim 1 and wherein said structural subassembly comprises mechanical connecting means for connecting together said structural assemblies and for providing structural stability.

19. A modular structural assembly according to claim 18 and wherein said mechanical connecting means snap into said structural assemblies.

20. A modular structural assembly according to claim 1 and also including flat plate connector means joinable to said structural subassembly.

21. A modular structural assembly according to claim 20 and

wherein said flat plate connector means includes insulation means.

22. A modular structural assembly according to claim 20 and wherein said flat plate connector means includes a lighting means formed of a sodium impregnated sheet and a potassium impregnated sheet.

23. A modular structural assembly according to claim 20 and wherein said flat plate connector means includes an electrical circuit board.

24. A modular structural assembly according to claim 1 and also including sensors for measuring at least levelness, temperature, humidity and air pressure.

25. A building comprising:

a multiplicity of generally identical modular structural elements to be connected to each other, each comprising:

a structural subassembly having an inner volume and being mechanically connectable with neighboring structural assemblies to define structure of said building, said structural subassembly having a plurality of conduit connection apertures distributed at least about the periphery thereof; and

a utility subassembly locatable within said inner volume, said utility subassembly having a plurality of conduits extending from at least one junction in a plurality of directions, said conduits being selectably connected together and locatable through said conduit connection apertures for connection to corresponding utility subassemblies of said neighboring generally identical modular structural assemblies.

26. A building according to claim 25 and including adjustable foundation support means.

27. A building according to claim 25 and including at least

one pyramidal piece forming part of foundation support means.

28. A building according to claim 25 and including a water collection and circulation system.

29. A building according to claim 25 wherein said building has a sealed roof surface formed only of flashing and counter-flashing subassemblies.

30. A building according to claim 25 and characterized in that it is generally air tight.

31. A supporting column comprising:

a multiplicity of generally identical modular structural elements to be connected on top of each other as in a vertical stack, each comprising:

a structural subassembly having an inner volume and being mechanically stackable and connectable with neighboring structural assemblies to define structure of said supporting column, said structural subassembly having a plurality of conduit connection apertures distributed at least about the surfaces thereof; and

a utility subassembly locatable within said inner volume, said utility subassembly having a plurality of conduits extending from at least one junction in a plurality of directions, said conduits being selectably connected together and locatable through said conduit connection apertures for connection to corresponding utility subassemblies of said neighboring generally identical modular structural assemblies.

32. A supporting beam comprising:

a multiplicity of generally identical modular structural elements to be connected on top of each other as in an horizontal stack, each comprising:

a structural subassembly having an inner volume and

being mechanically stackable and connectable with neighboring structural assemblies to define structure of said supporting beam, said structural subassembly having a plurality of conduit connection apertures distributed at least about the surfaces thereof; and

a utility subassembly locatable within said inner volume, said utility subassembly having a plurality of conduits extending from at least one junction in a plurality of directions, said conduits being selectably connected together and locatable through said conduit connection apertures for connection to corresponding utility subassemblies of said neighboring generally identical modular structural assemblies.

33. A removable utility subassembly connectable to other utility subassemblies comprising:

a plurality of conduits extending from at least one junction in a plurality of directions; and

at least one junction box located in at least one of said at least one junction for selectably connecting said plurality of conduits to each other.

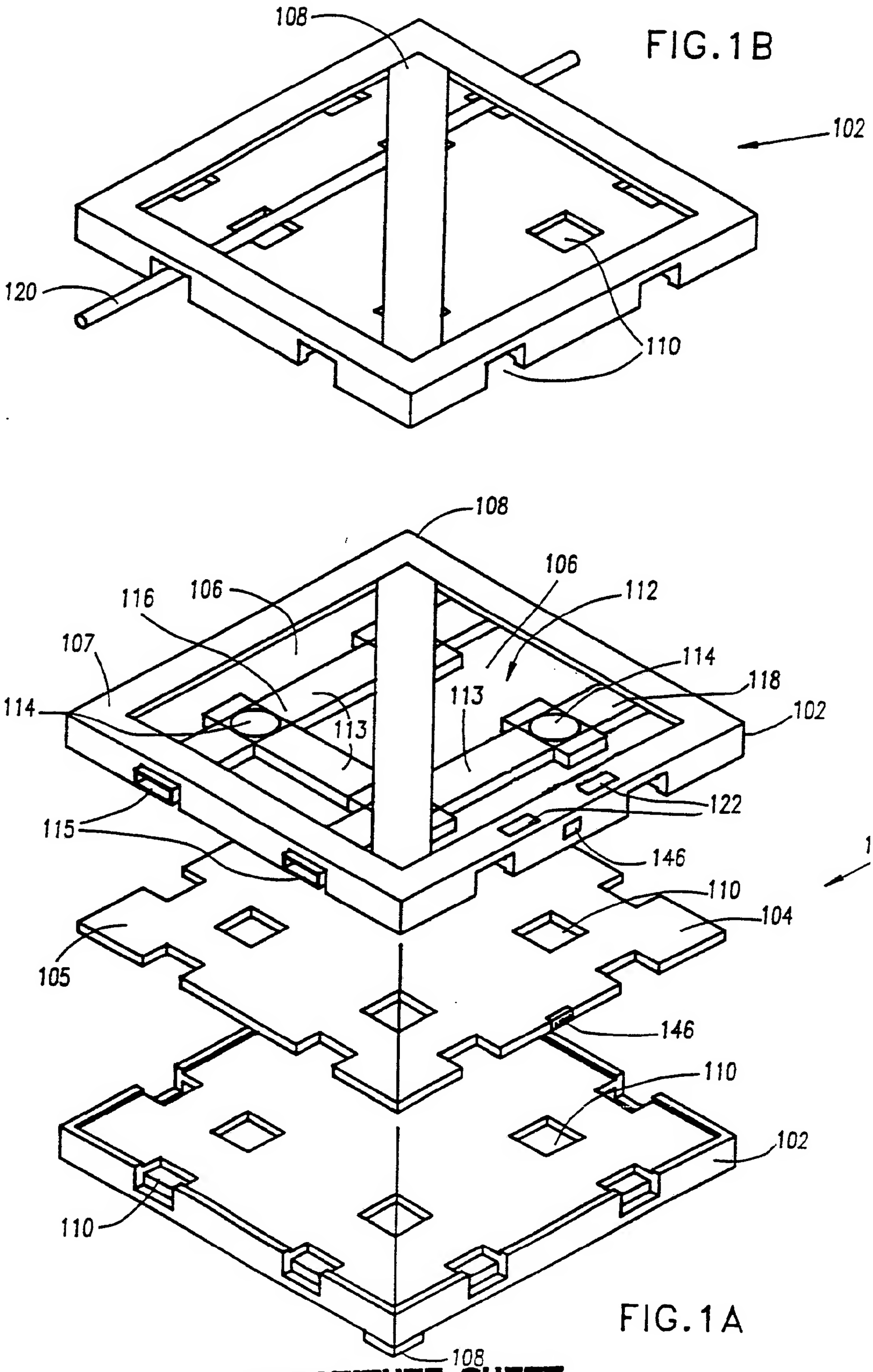
34. A modular structural assembly for connection with other neighboring generally identical modular structural assemblies to create a surface of an existing building structure, the modular structural assembly comprising:

a structural subassembly having an inner volume and being mechanically connectable with said neighboring structural assemblies and said existing building structure, said structural subassembly having a plurality of conduit connection apertures distributed at least about the periphery thereof; and

a utility subassembly locatable within said inner volume, said utility subassembly having a plurality of conduits extending from at least one junction in a plurality of directions, said conduits being selectably connected together and locatable through said conduit connection apertures for connection to corresponding utility subassemblies of said neighboring

generally identical modular structural assemblies.

35. A window frame comprising:
a frame housing; and
air ventilation louvers integrally formed with said housing.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102
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112
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114
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108

FIG. 1B

FIG. 1A

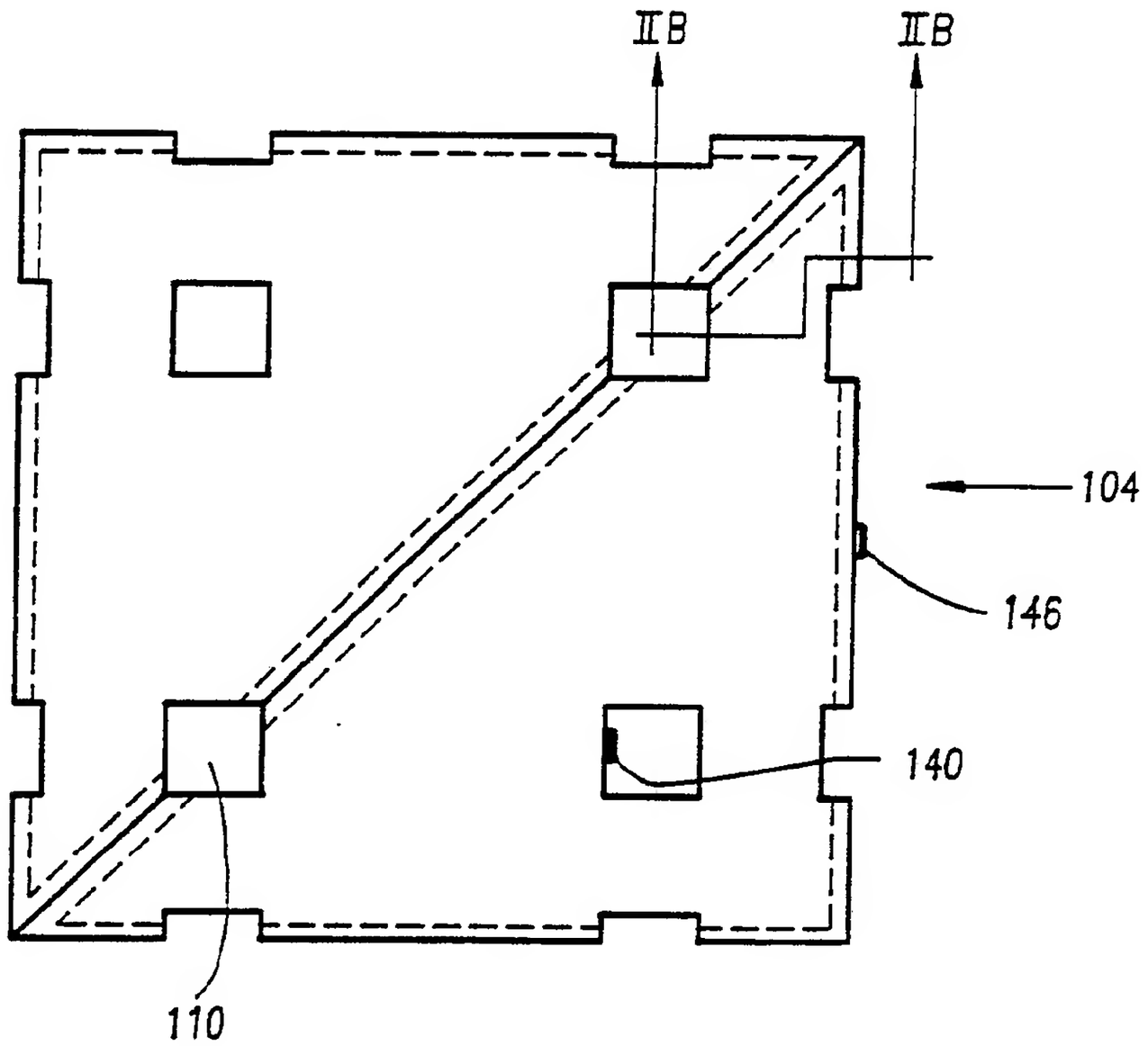


FIG.2A

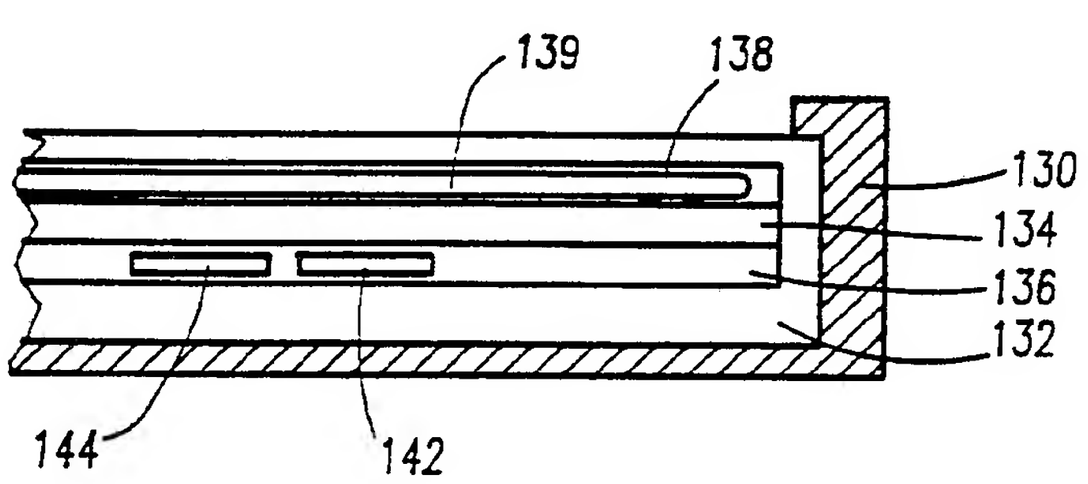


FIG.2B

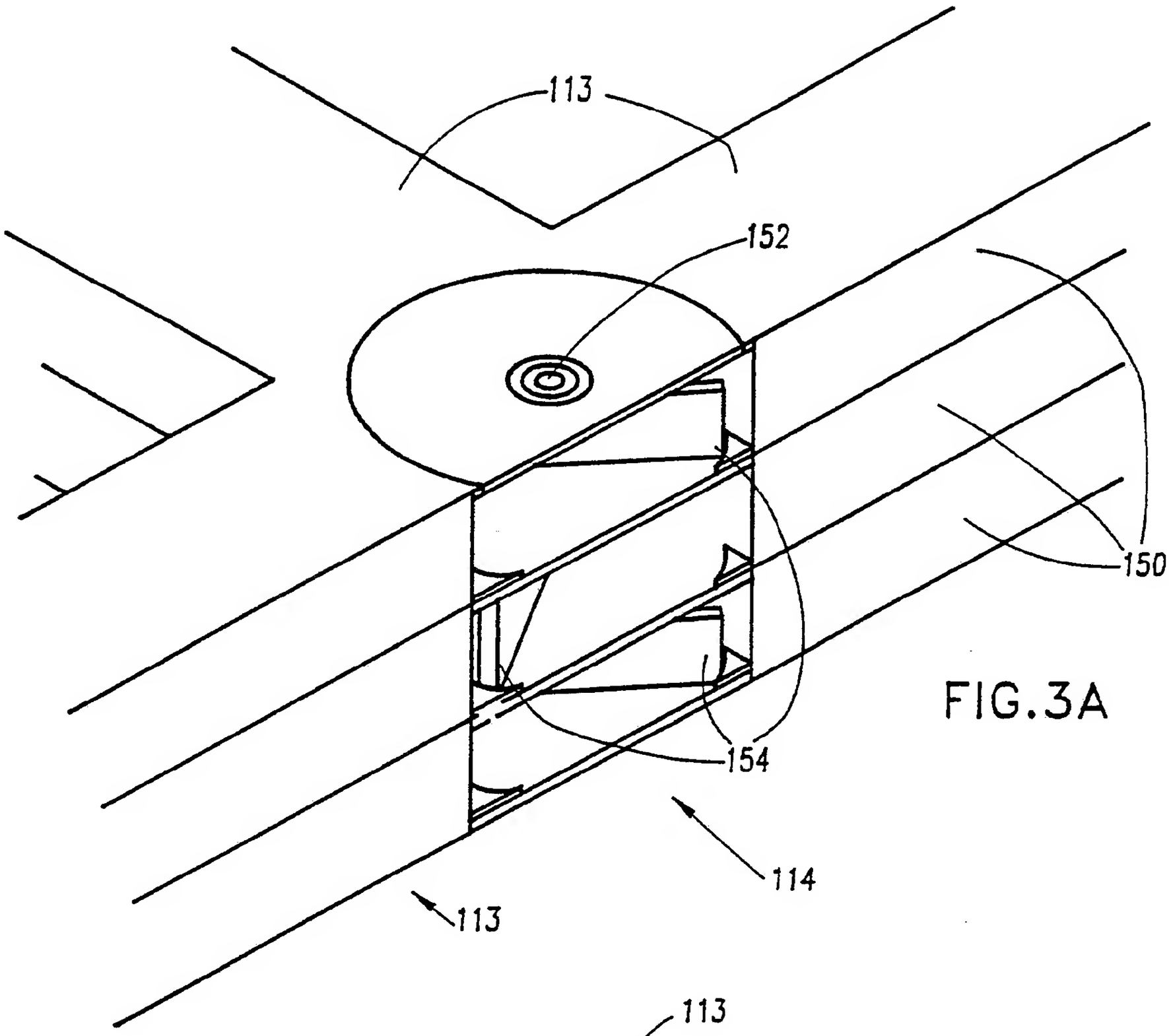


FIG.3A

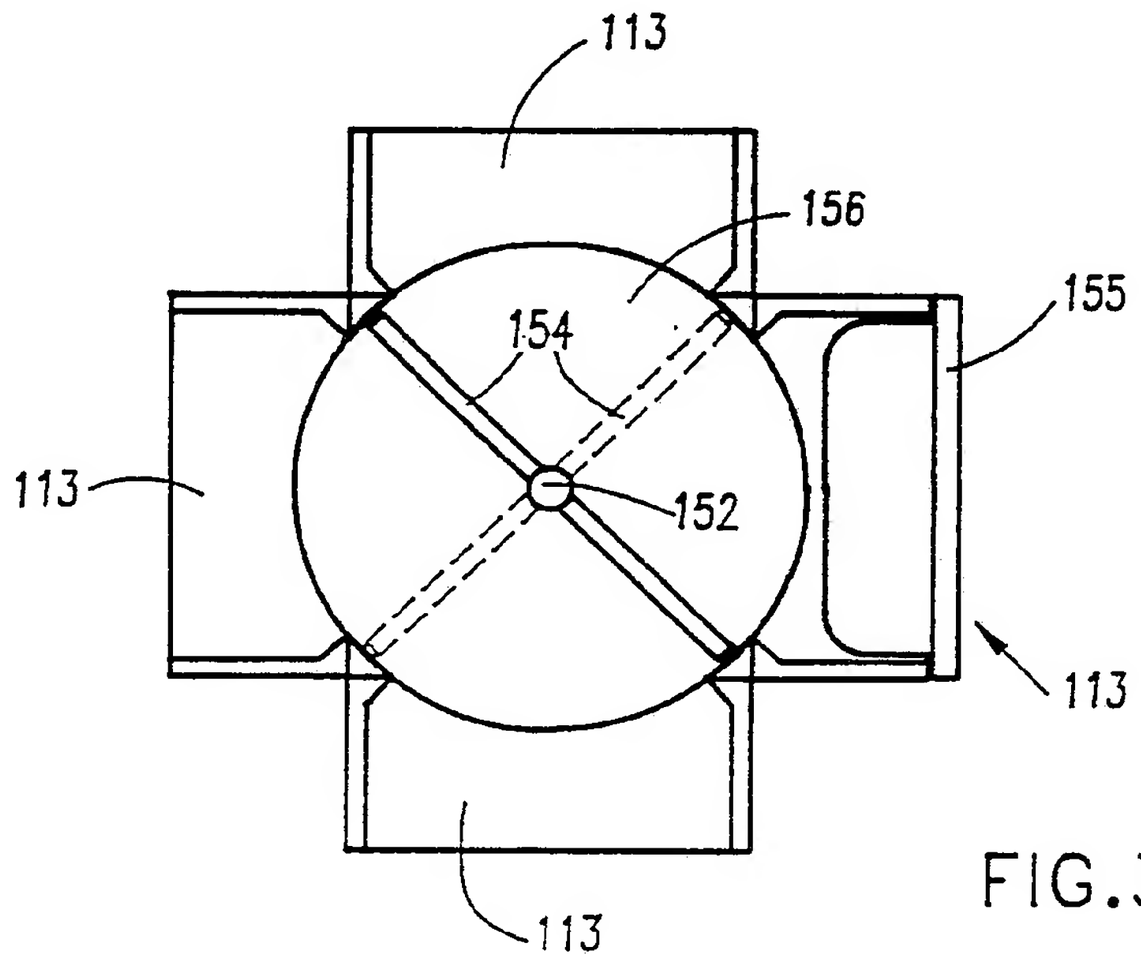


FIG.3B

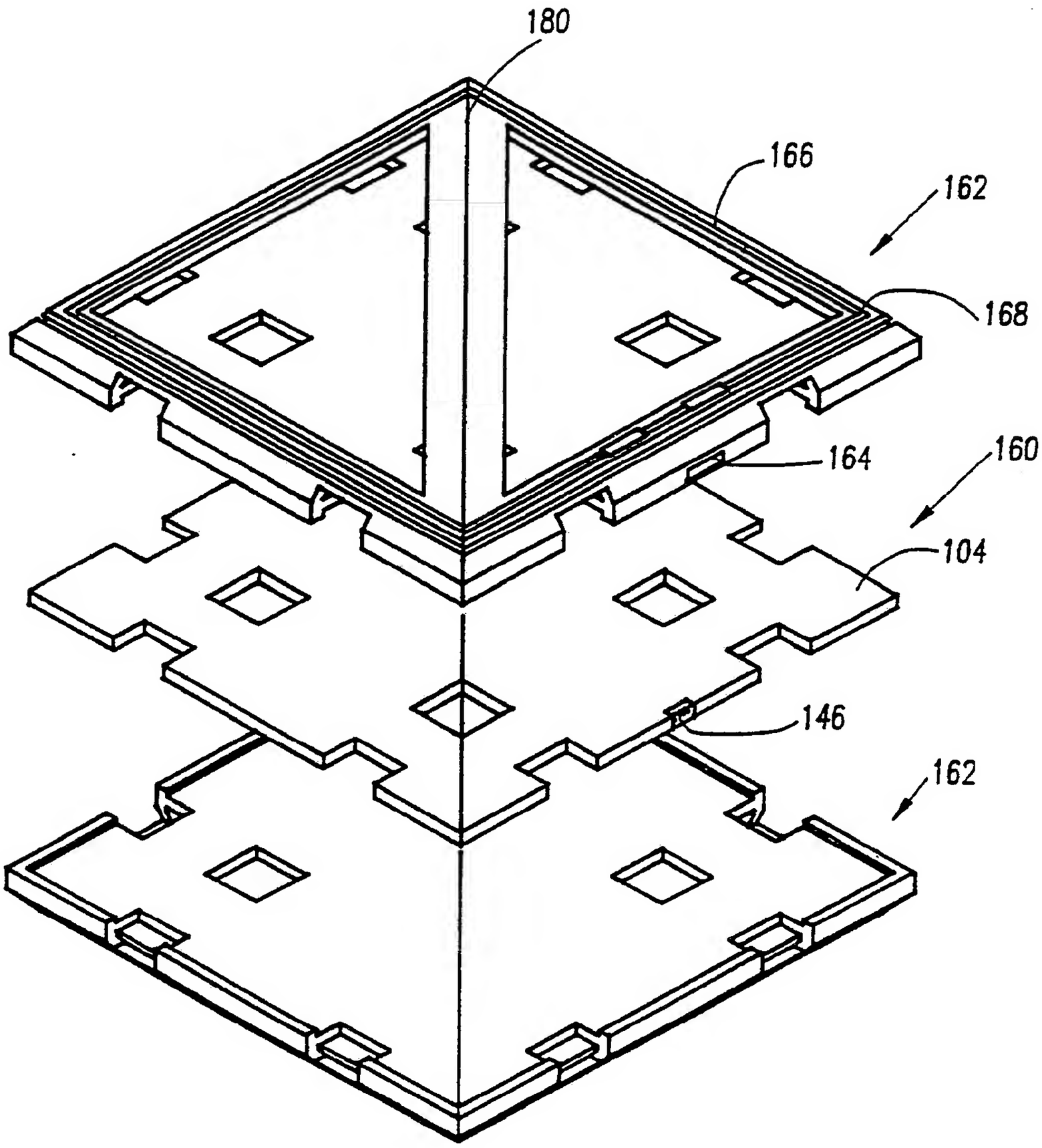
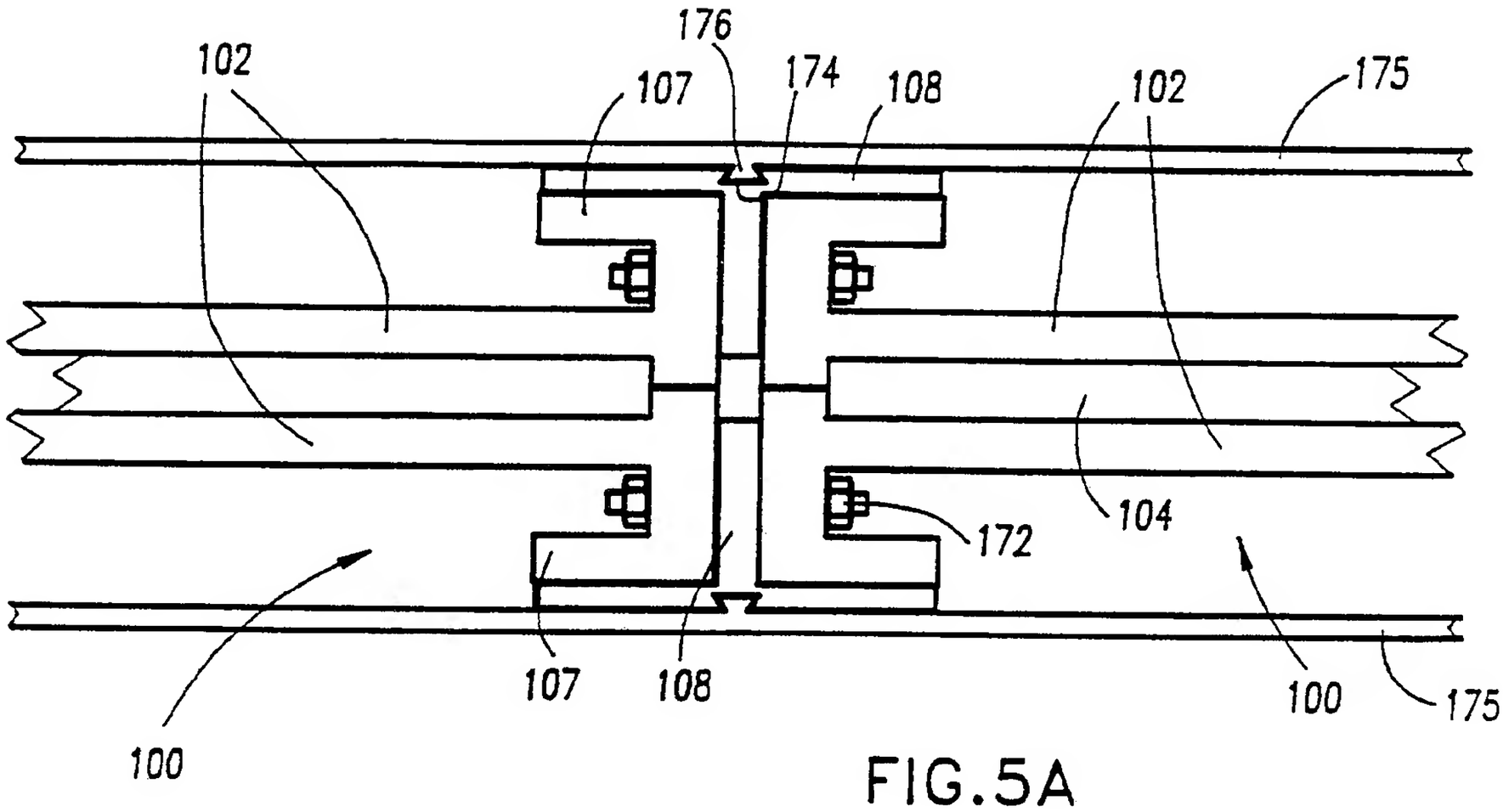


FIG.4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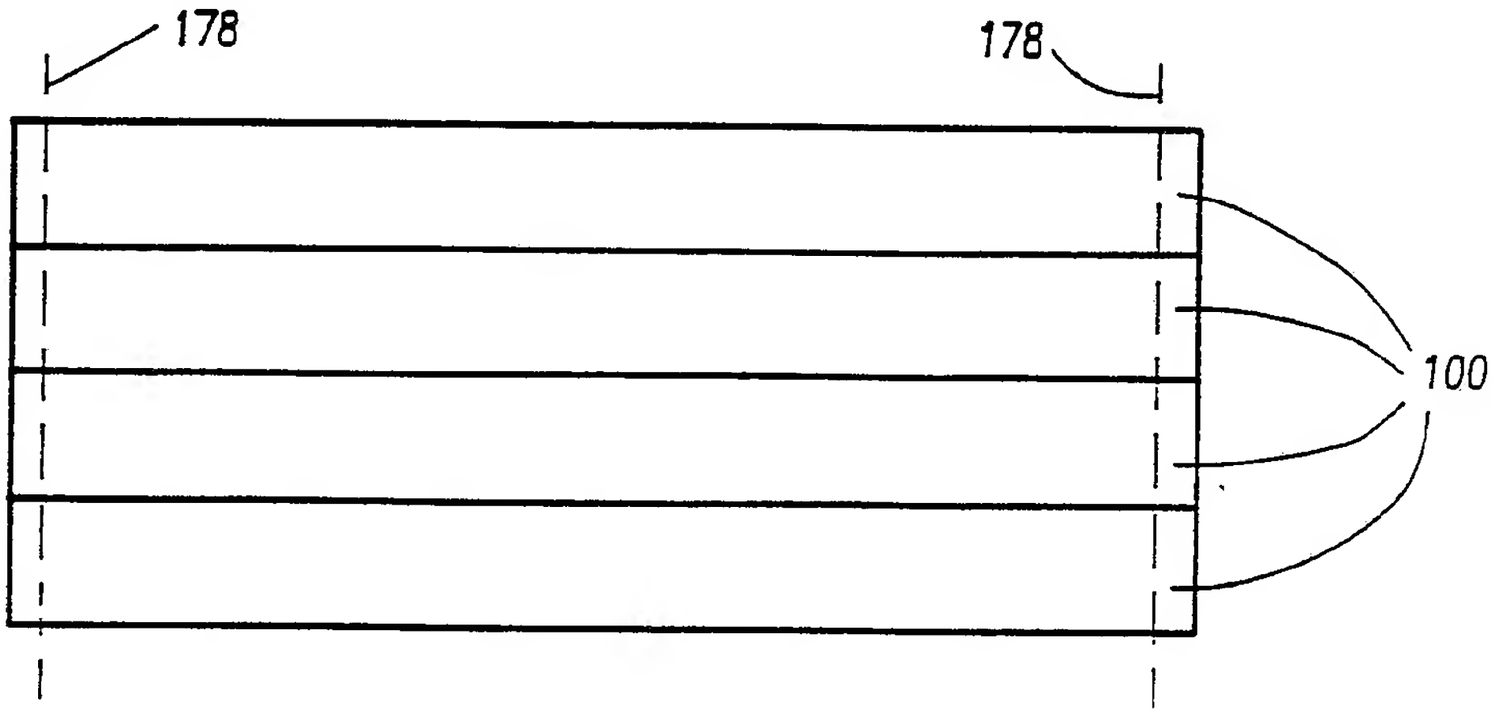
102
107
174
108
102
175
104
172
107
108
100
100
175

FIG.5A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178
100

FIG.5B

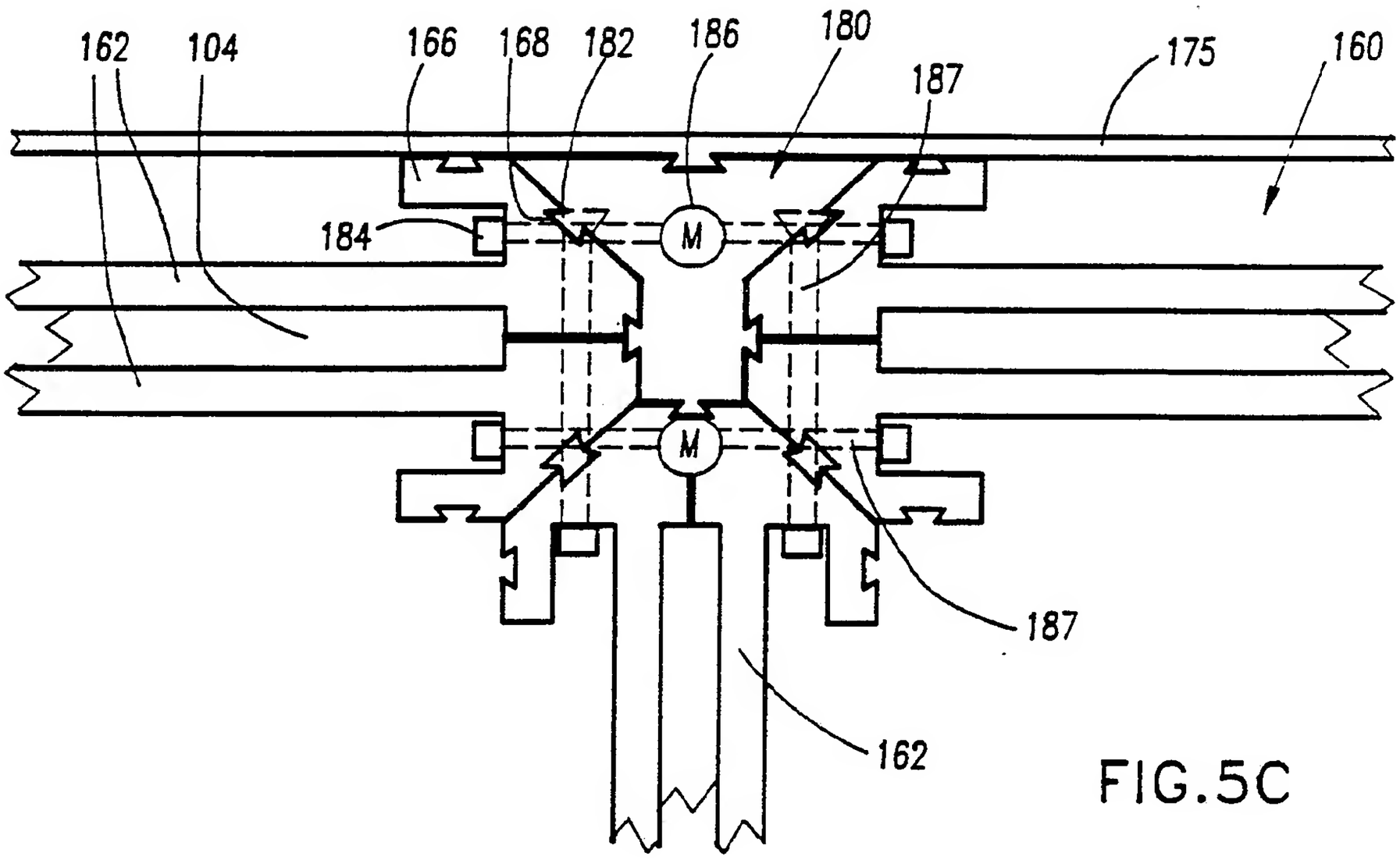

162
104
166
168
182
186
180
187
175
160
184
M
M
187
162

FIG.5C

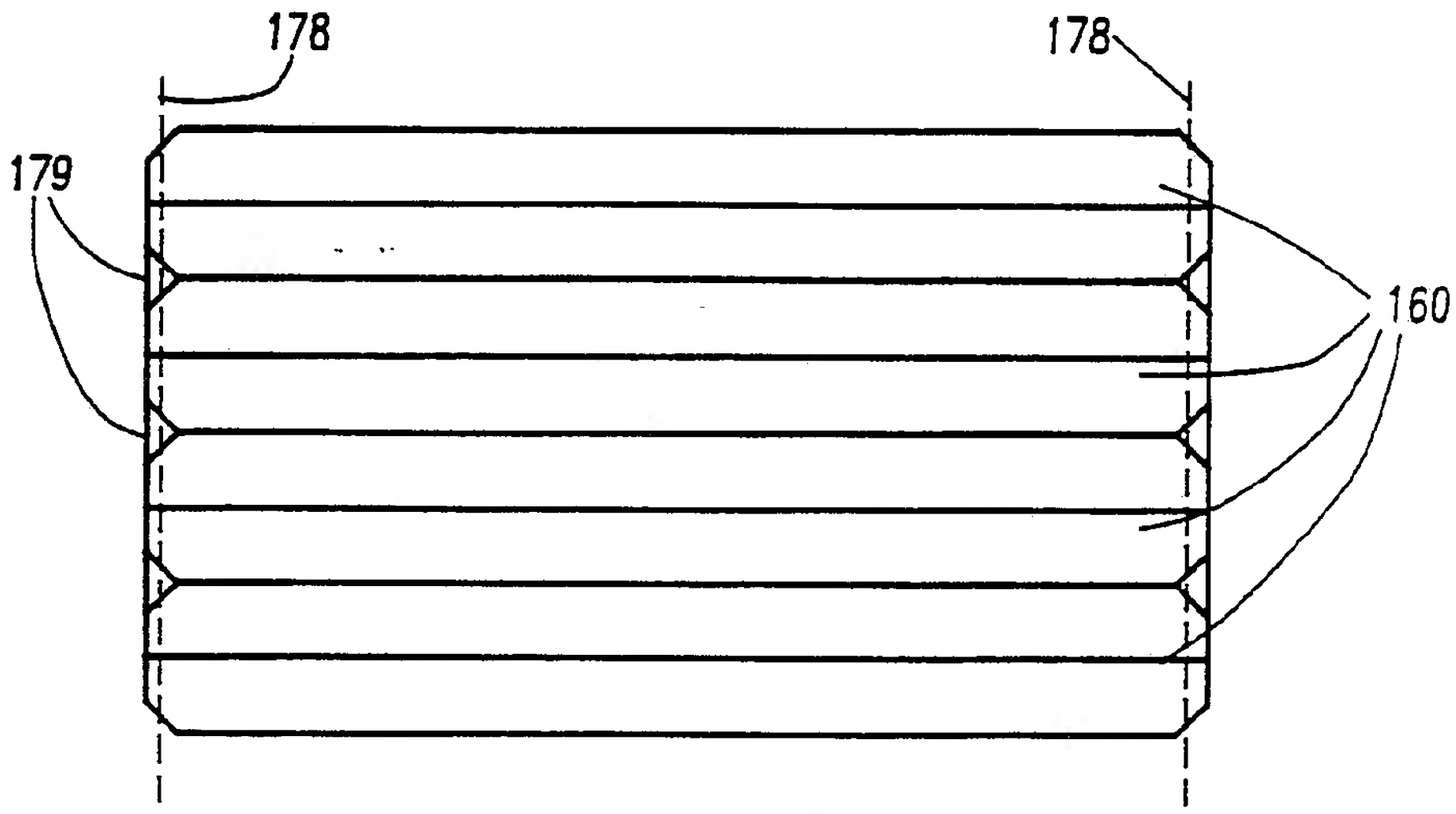
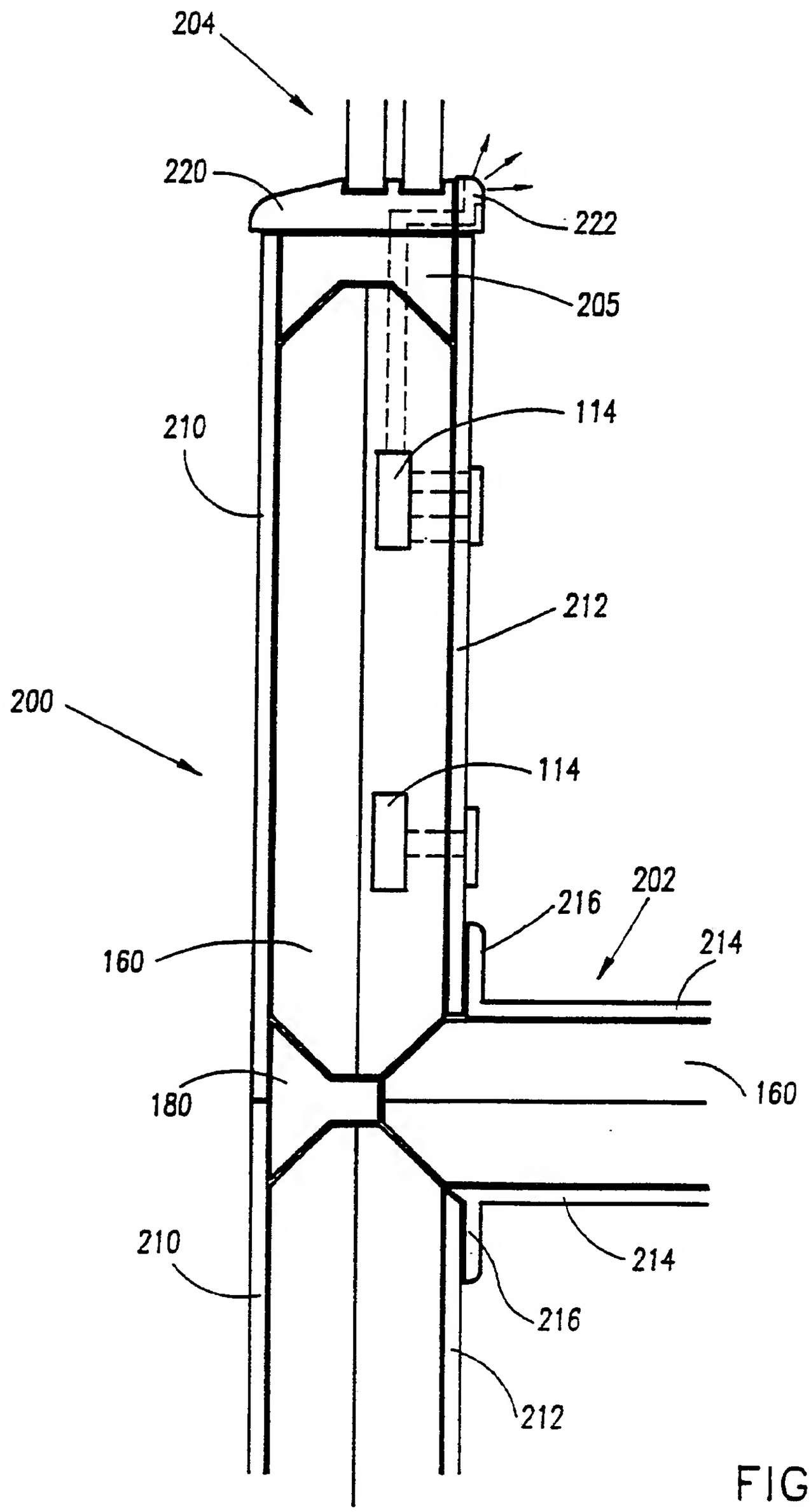

178
178
179
160

FIG.5D


204
220
222
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210
114
212
200
114
216
202
214
160
180
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210
214
216
212

FIG.6

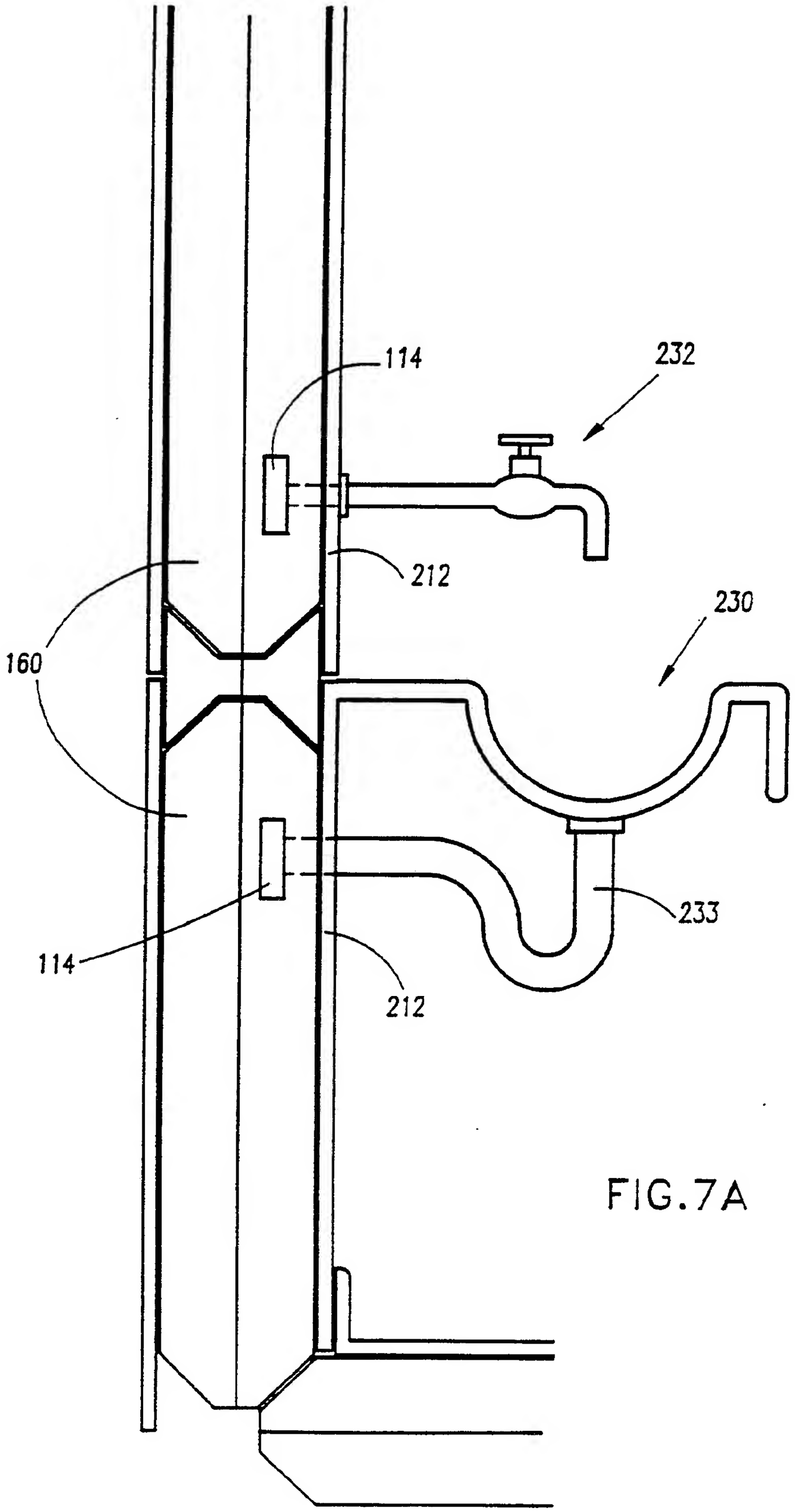


FIG.7A

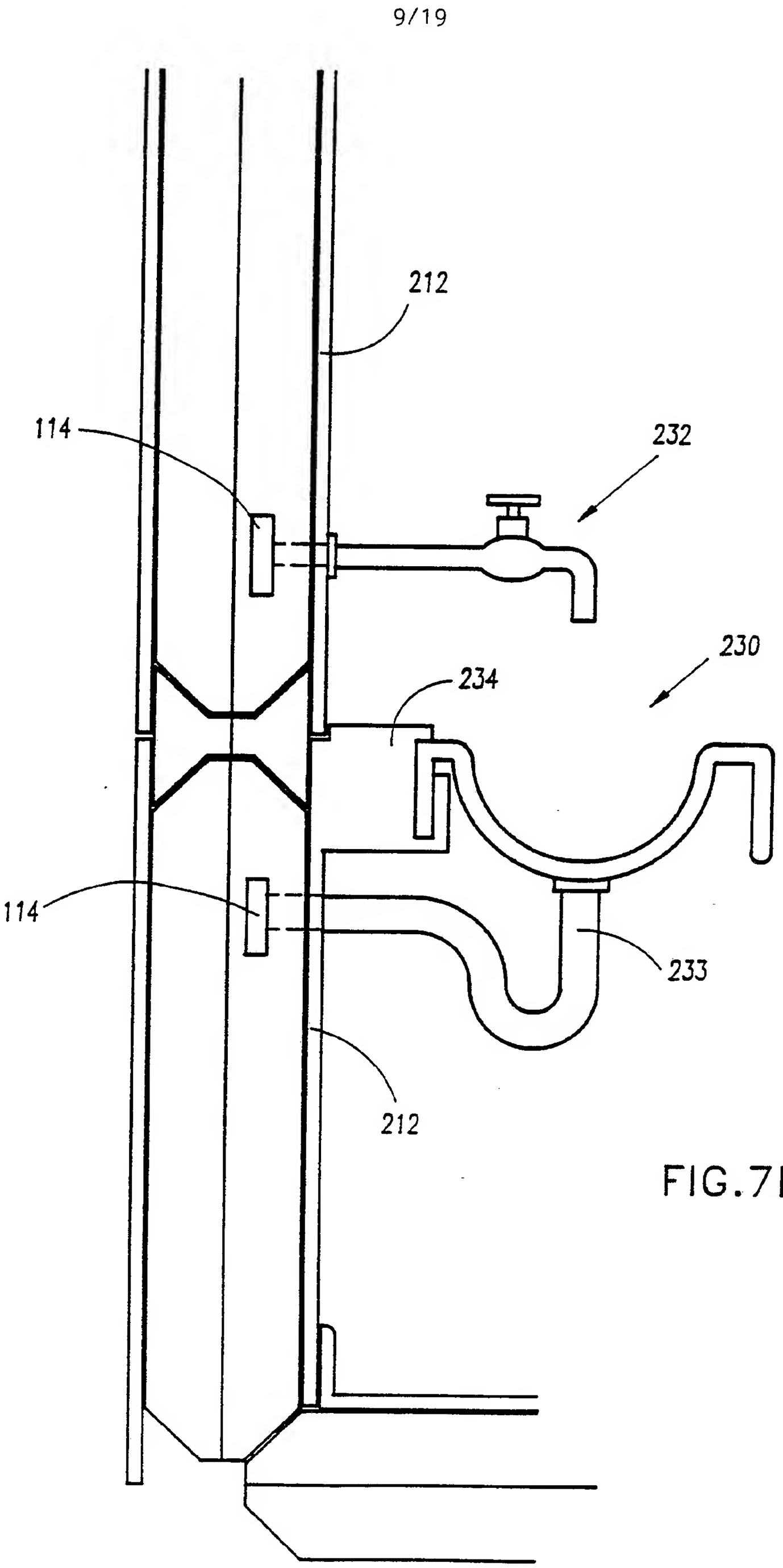
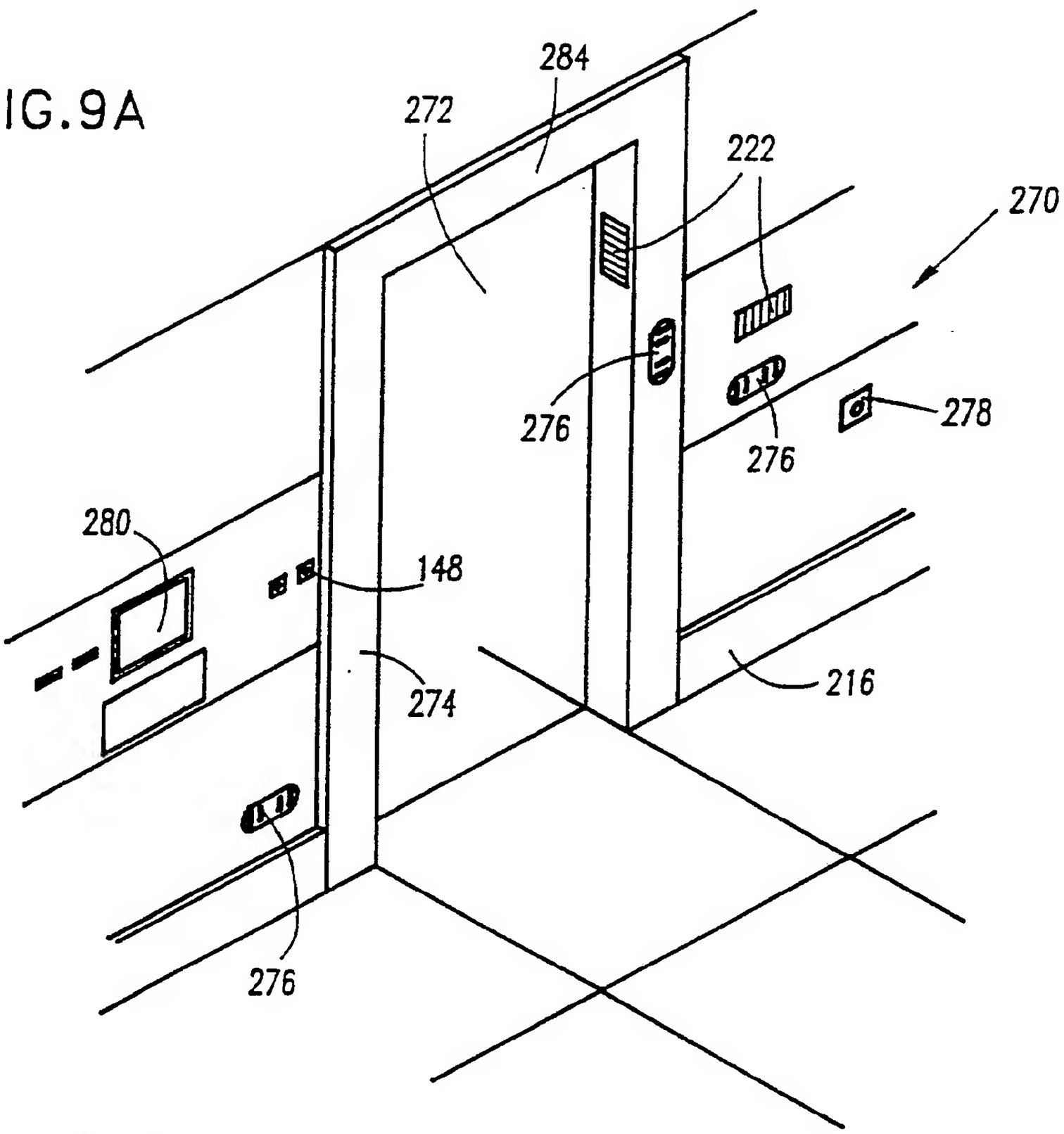


FIG.7B

FIG.9A


284
272
222
270
276
278
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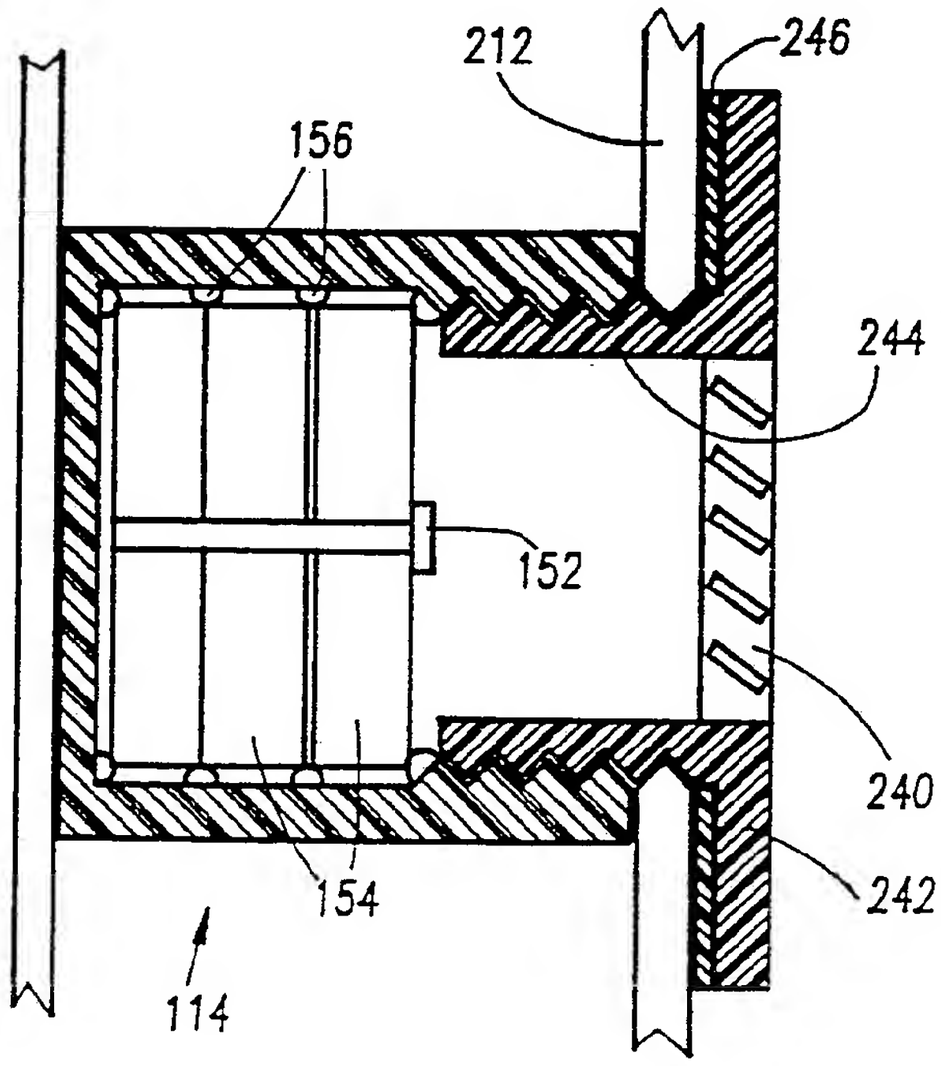
280
148
274
216
276


212
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156
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242
154
114

FIG.7C

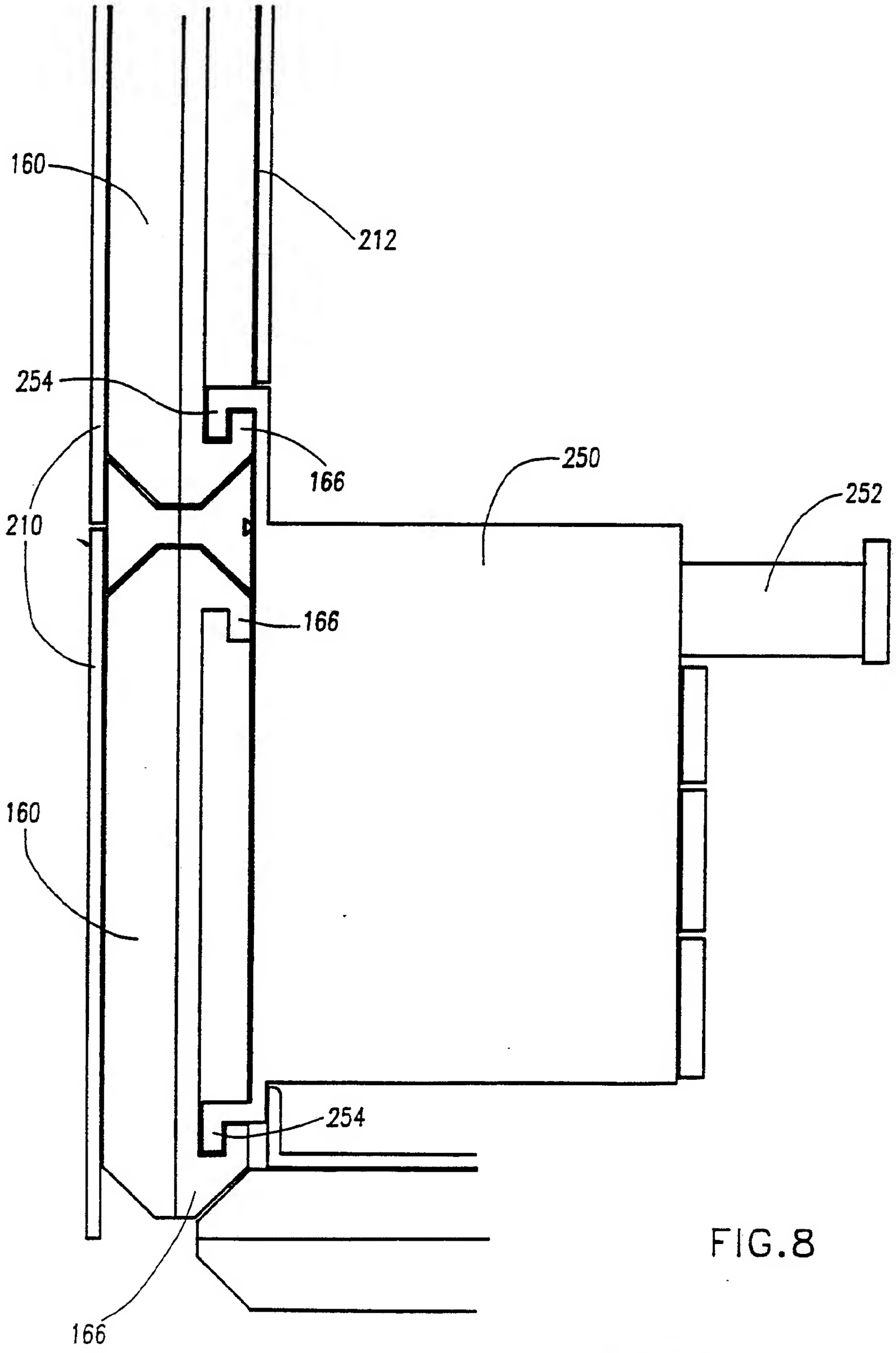


FIG.8

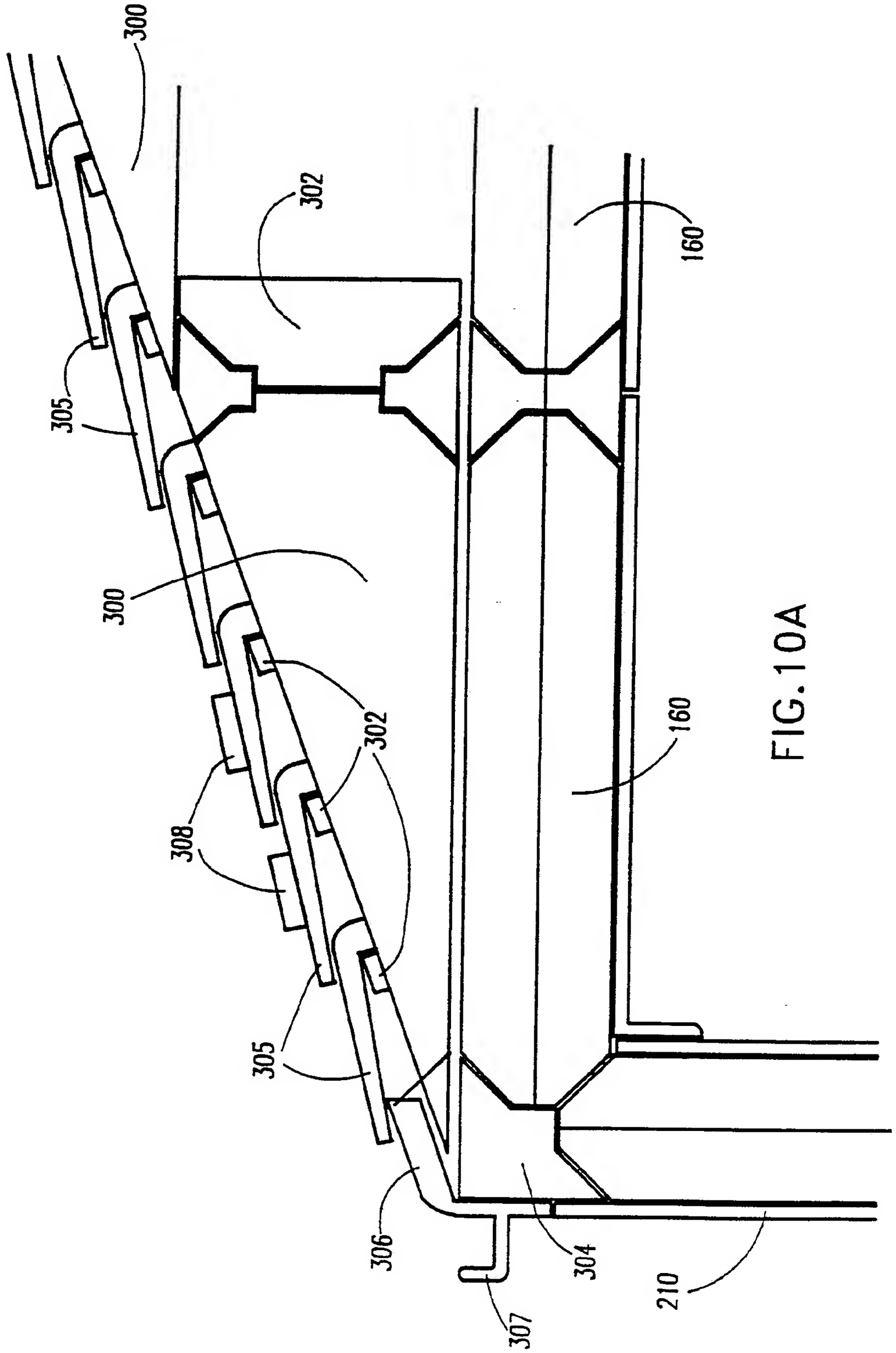
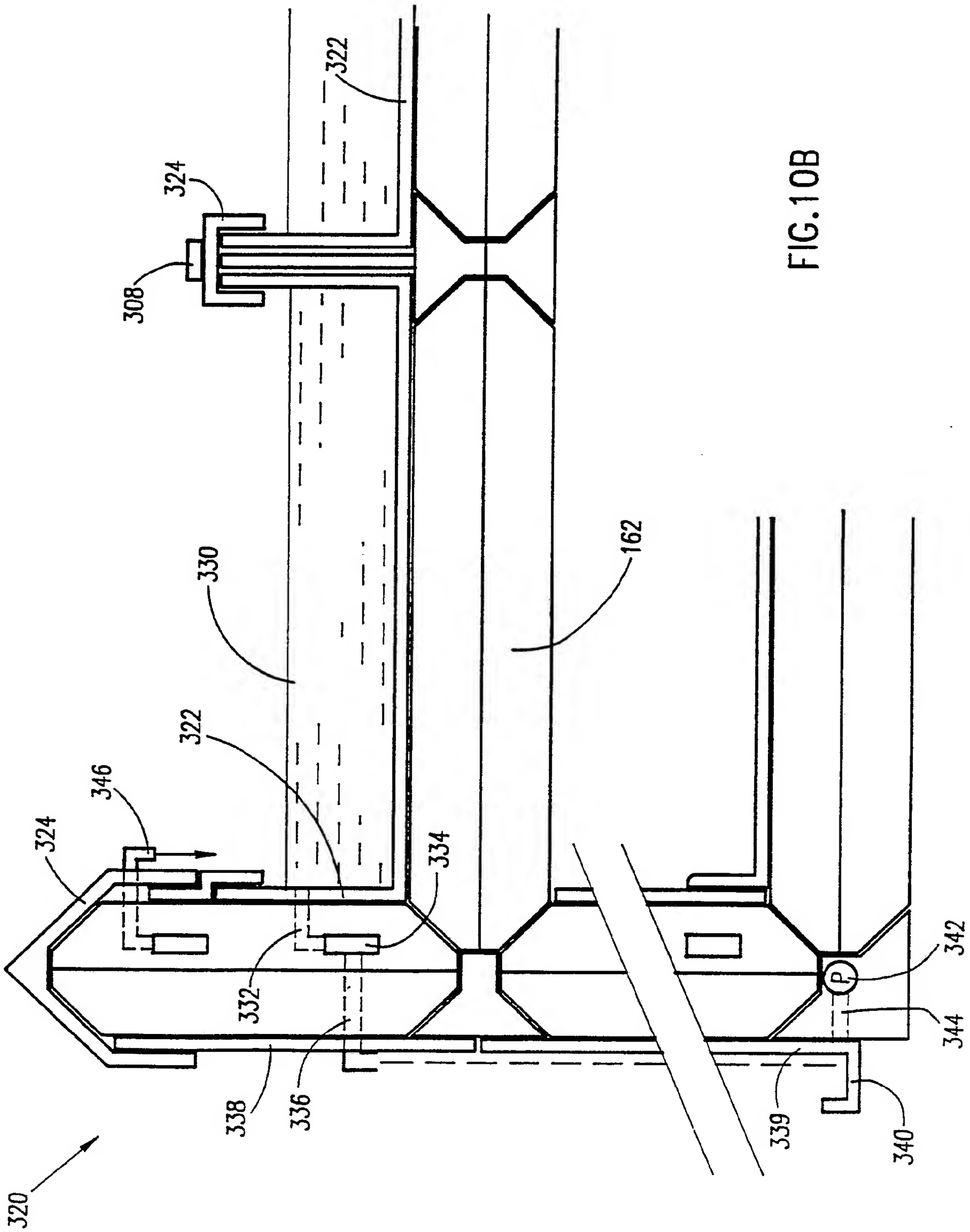


FIG.10A


322
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308
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162
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340
320

FIG.10B

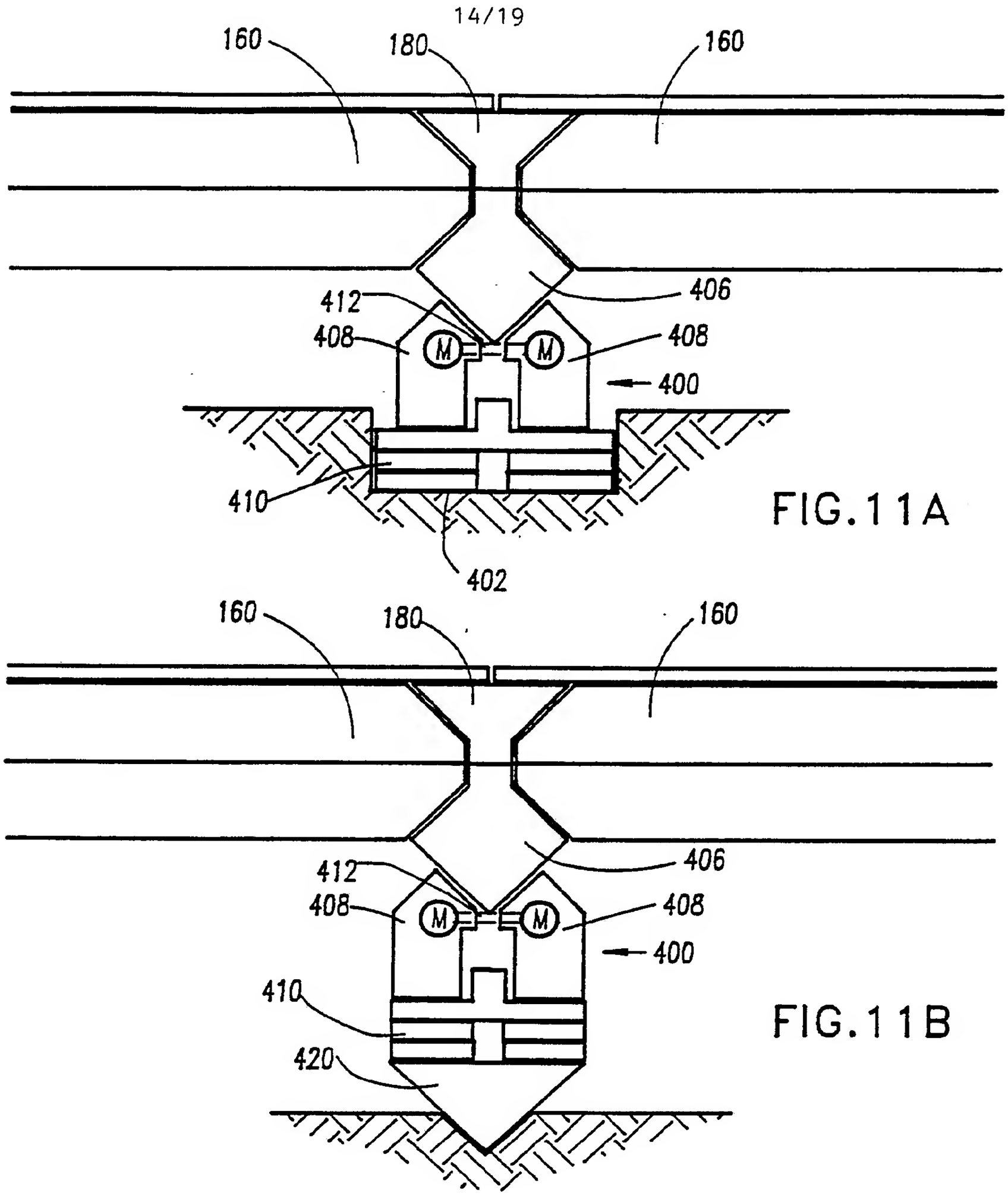


FIG. 11A

FIG. 11B

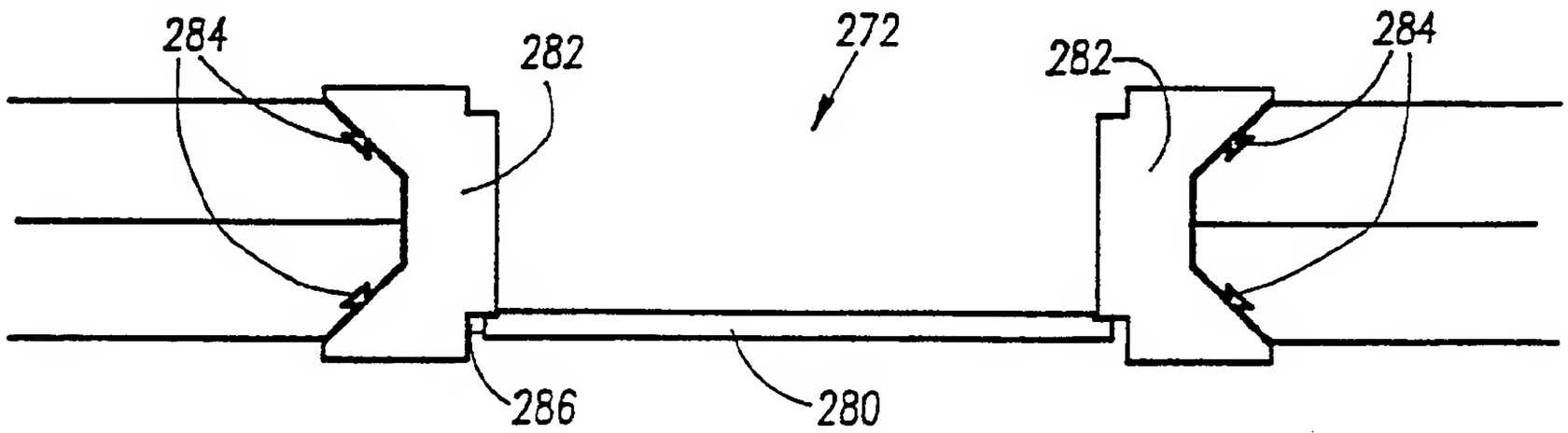


FIG. 9B

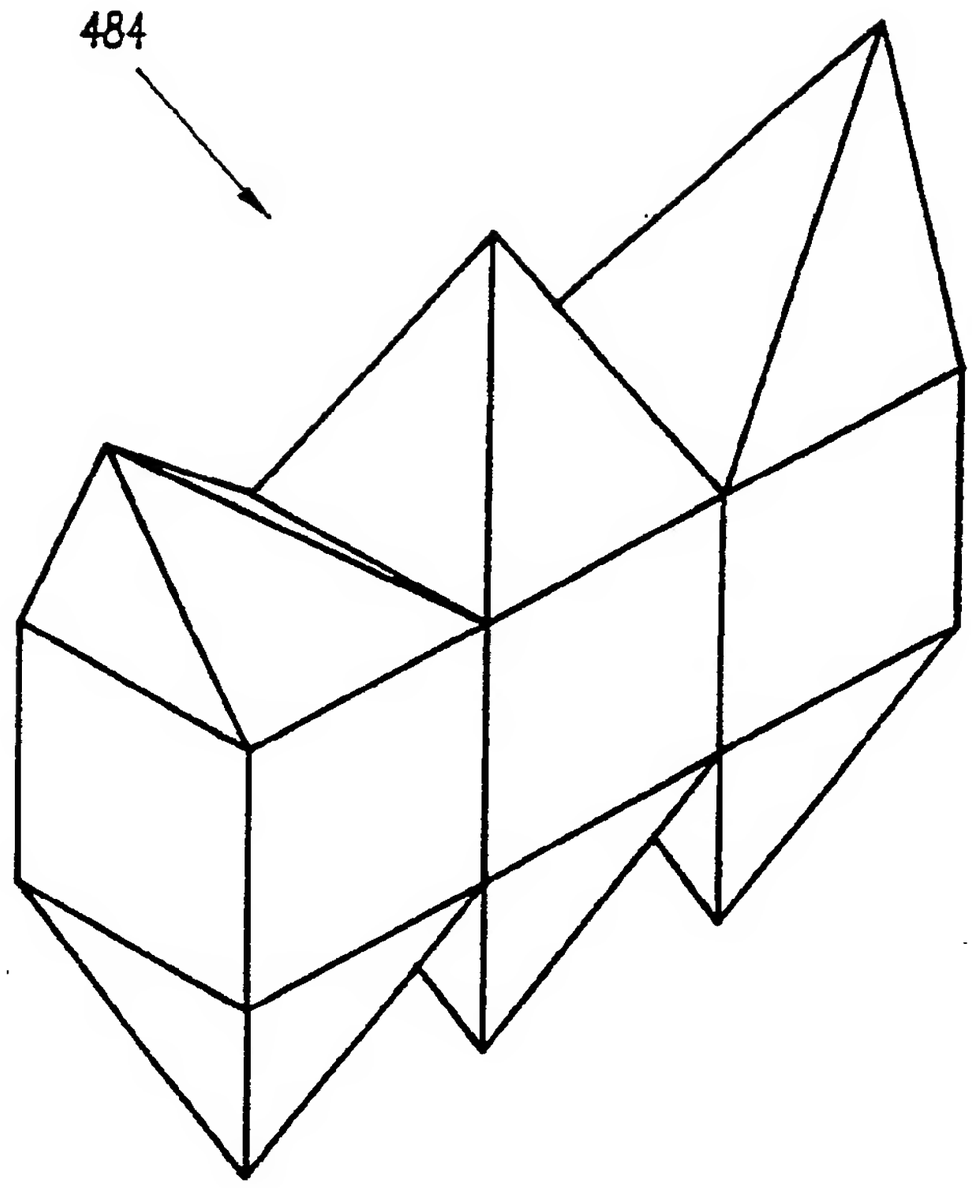


FIG. 13C

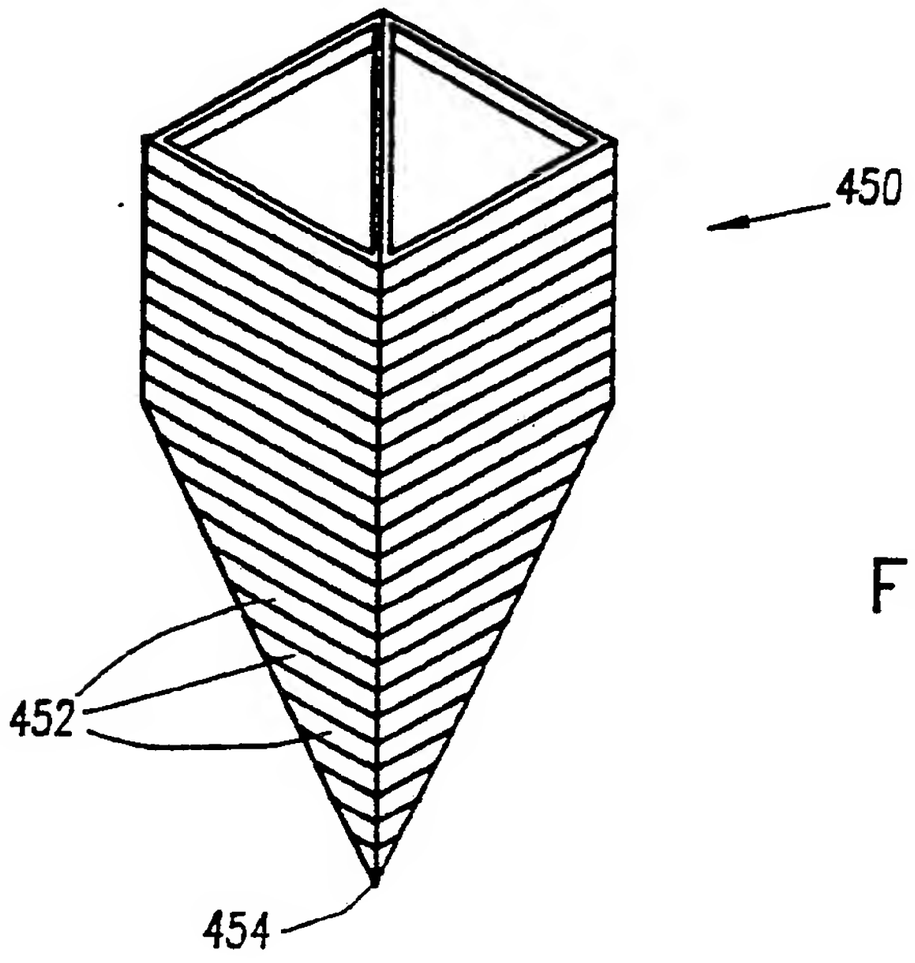


FIG. 11C

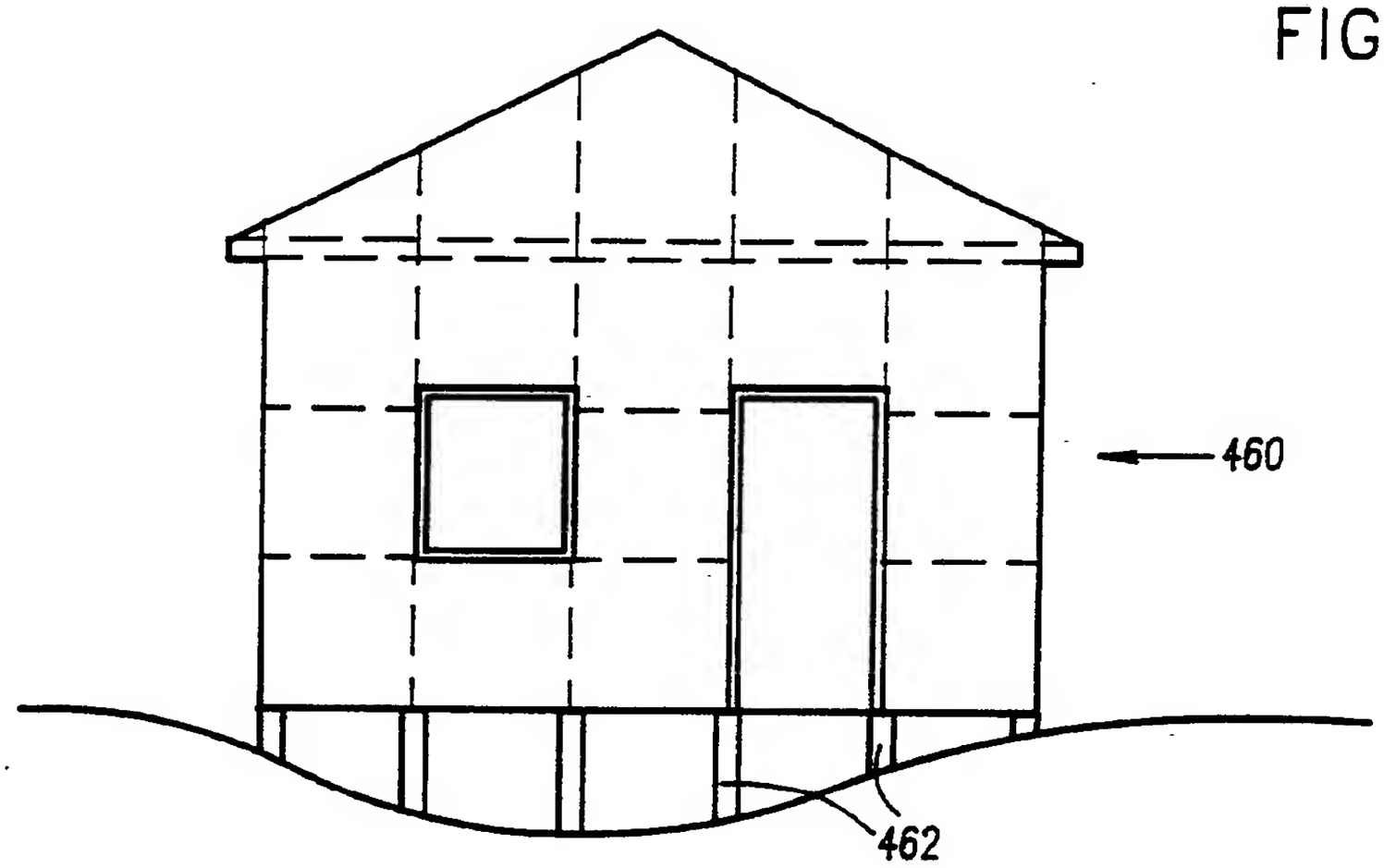


FIG.12A

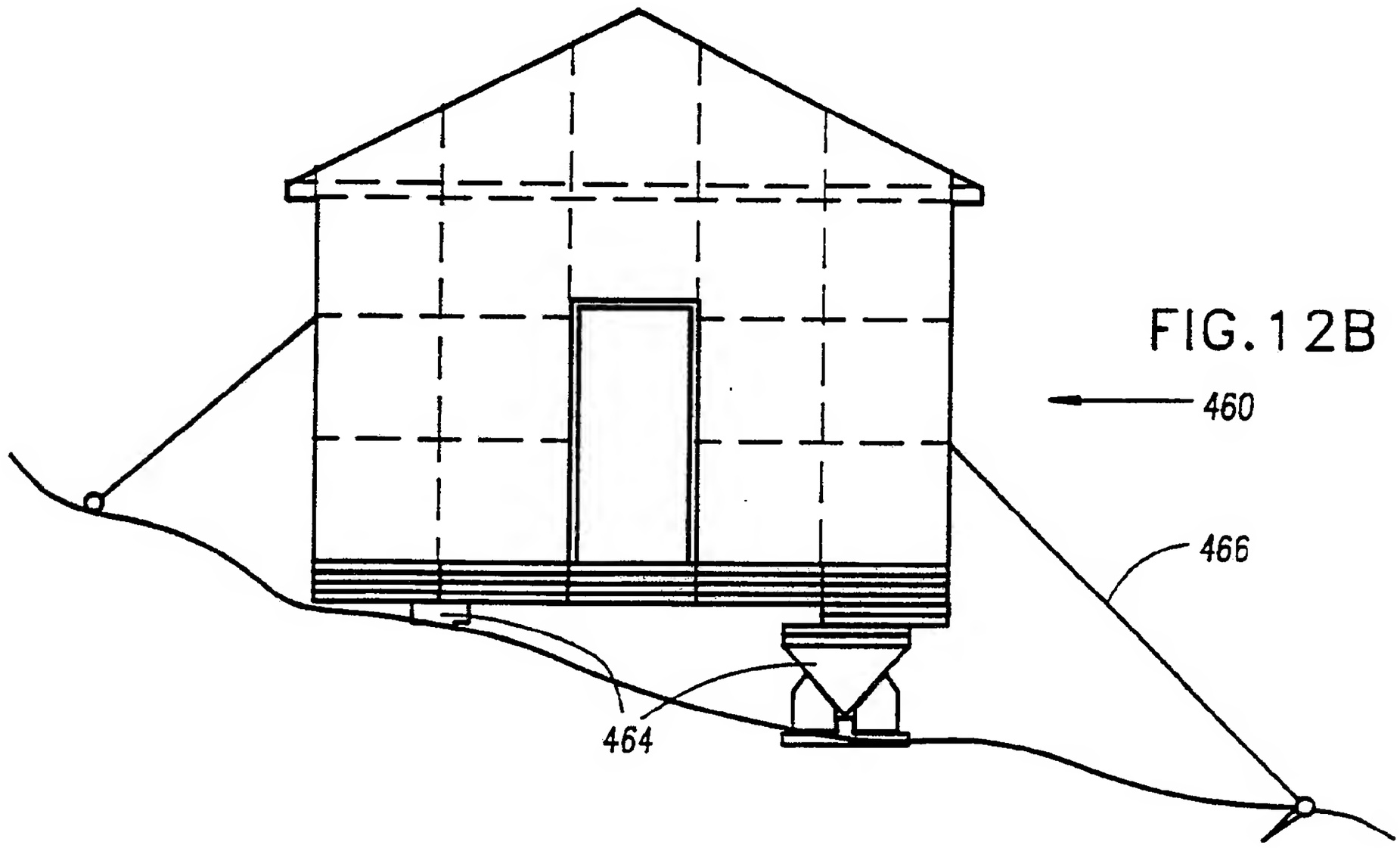
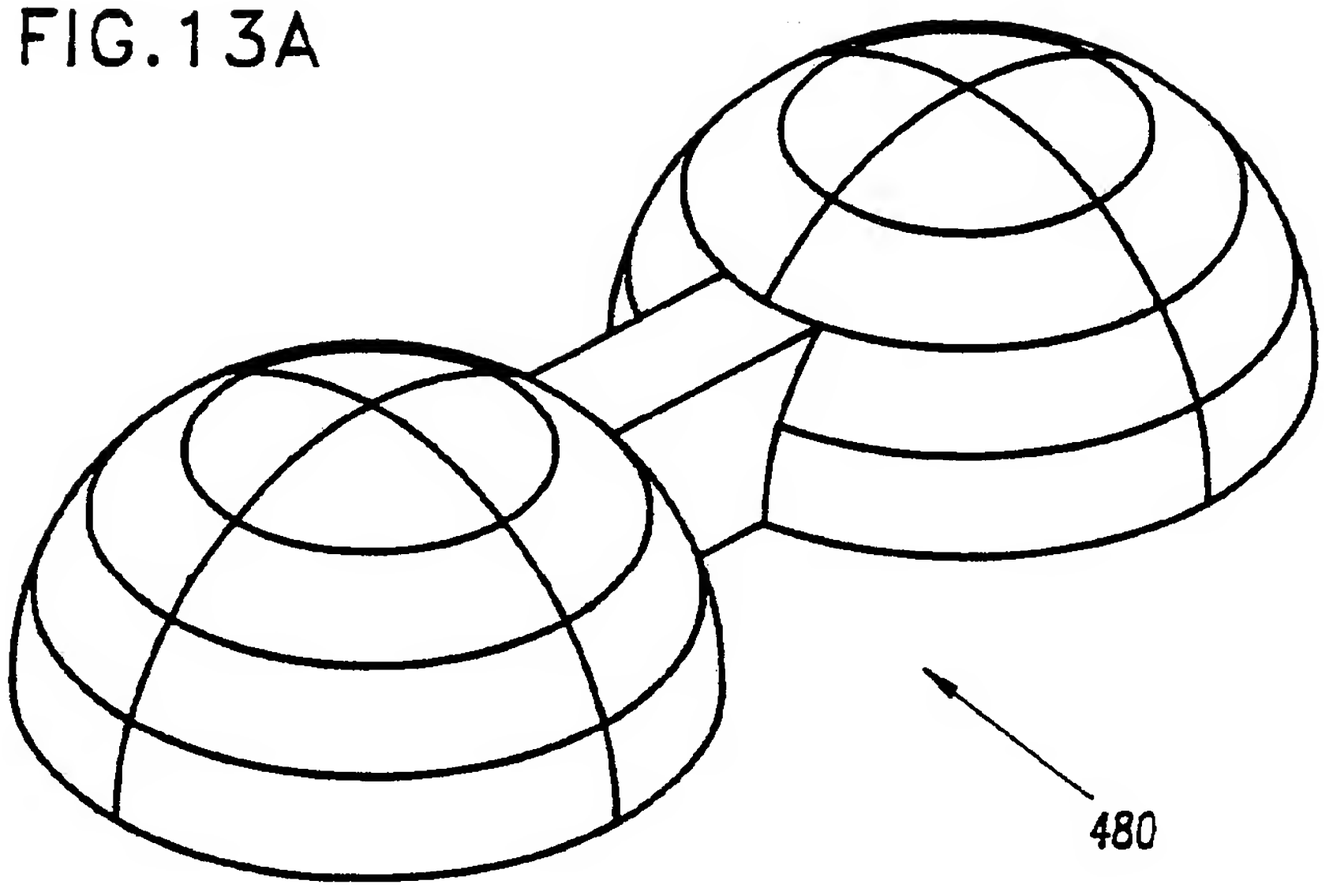


FIG.12B

FIG.13A



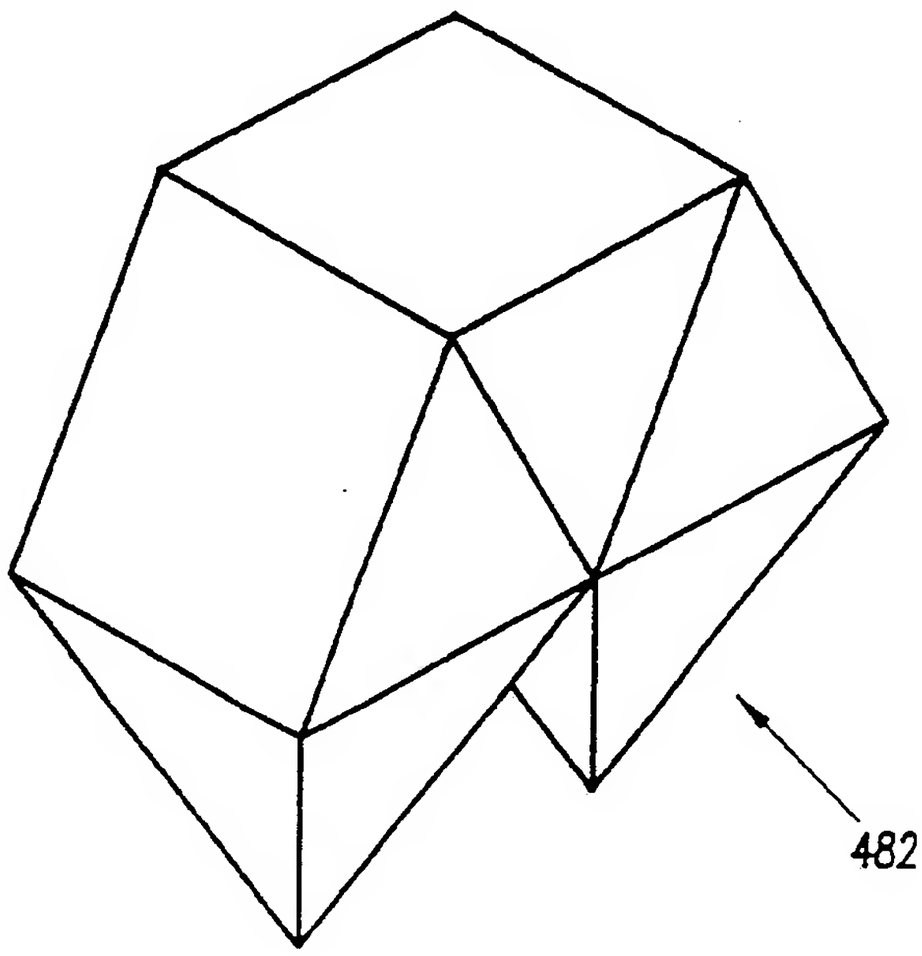


FIG.13B

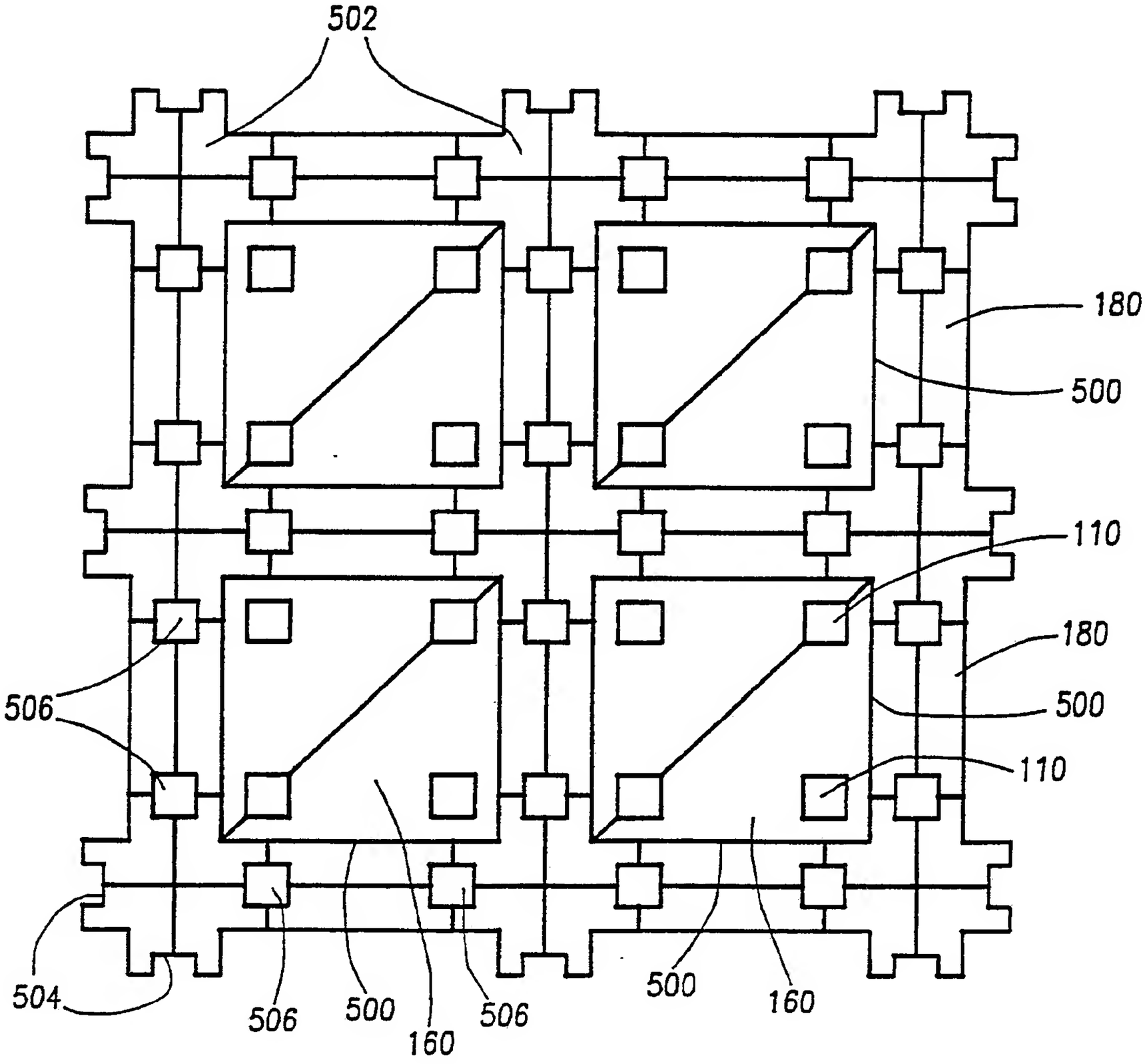


FIG.14

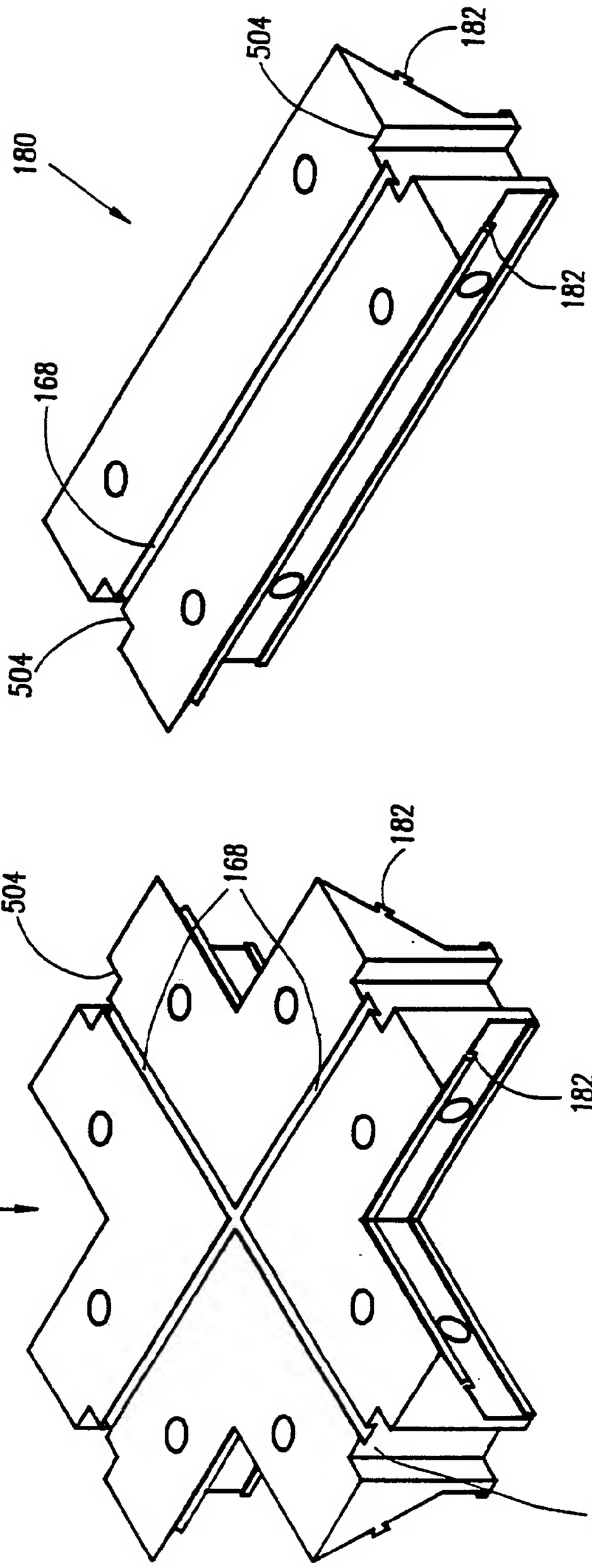


FIG. 15A

FIG. 15B

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US91/04141

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(5): E04B 5/48
US CL : 52/221

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
US CL.	52/79.1,220,221// 174/48,49

Documentation Searched other than Minimum Documentation
to the Extent that such Documents are included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	SU, A, 601,364 (SOLOVEV) 05 NOVEMBER 1978	1-3,5-7,9,11-16,18-22,26-34
X	DE, A, 3,616,733 (BRUGGEMANN) 17 MAY 1986	1-34
Y	US, A, 4,326,012 (CHARLETON) 20 APRIL 1982	1-34
Y	US, A, 2,419,319 (LANKTON) 22 APRIL 1947	1-34
Y	US, A, 4,201,024 (LAFITTE, JR.) 06 MAY 1980	1-34
Y	US, A, 4,272,930 (FOSTER) 16 JUNE 1981	

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
19 SEPTEMBER 1991	05 NOV 1991
International Searching Authority	**Signature of Authorized Officer**
ISA/US	MICHELE A. VAN PATTEN

Form PCT/ISA/210 (second sheet) (Rev.11-87)

DC 11-01-91

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

V ☒ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers because they relate to subject matter [2] not required to be searched by this Authority, namely:

2. ☒ Claim numbers 35, because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [3], specifically:

There is no disclosure or drawing to support the claim.

3. ☐ Claim numbers _____, because they are dependent claims not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.